2010 U.S. Drinking Water Innovation Vendor Outlook

Report on the companies and market trends shaping innovation the U.S. drinking water sector

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Key Report Takeaways

Overall Water Market Takeaways:

- Innovation in the water sector is unanimously viewed as critical to meeting water challenges that will emerge in the 21st century. However, a large number of open questions remain around the speed at which innovation must occur, where financing of development will come from, and what types of companies are best positioned to address these emerging needs.
- Our analysis indicates that the total water equipment market in the U.S. in 2010 is ~$28 billion across drinking water, wastewater, and industrial water – a massive commercial opportunity for vendors, service providers, and innovators.

Venture Investment Takeaways

- Despite the size of this opportunity and interest on the part of venture investors, the water sector has significantly lagged other cleantech sectors in the amount of institutional venture capital devoted to companies in the industry.
- Venture capital (VC) investment in water has been particularly underrepresented in the United States; the U.S. typically garners ~60% of all global cleantech venture investment, yet has captured less than 30% of investments in the water sector in 2010.
- Venture investors have been hesitant to deploy significant capital in the sector due to perceived obstacles in penetrating large customers, uncertainty around regulation, long pilot cycles, opaque economics, and large capital needs to take some projects to scale.
- Venture investors have been attracted to opportunities targeting industrial water use where the sales cycles to commercial and industrial users is seen as more straightforward, as well as wastewater opportunities where by-products can be more easily monetized.
- U.S. government support, primarily in the form of stimulus-boosted increases to the State Drinking Water Revolving Funds, has resulted in positive momentum for infrastructure rehabilitation, but does not necessarily represent direct investment in next generation technologies.
- By virtue of its overall venture capital (VC) strength, California has garnered the majority of VC devoted to U.S. water innovators, but no U.S. region or municipality has seized on the opportunity to establish itself as a leading water innovation hub. This leaves the playing field open for the greater Cincinnati area to actively fill this void.

Drinking Water Market Dynamics

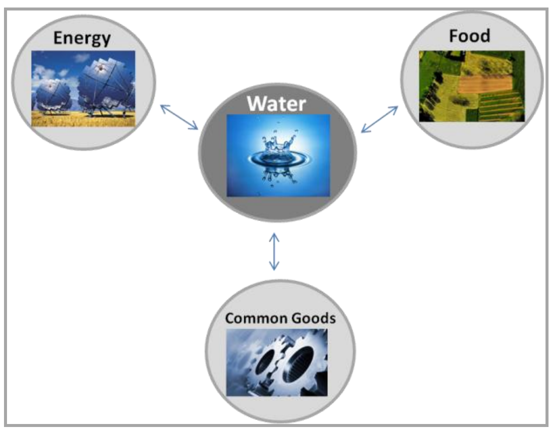
- Drinking water has been perhaps the most challenging market for new companies to enter. We classify innovation in the drinking water sector into three key areas: water treatment/disinfection, filtration/membrane treatment, and system monitoring & metering.
- Our analysis finds that the market opportunity in the U.S. drinking water sector distributed across these three key areas to be ~$1.2 billion.
- The drinking water value chain is dominated by large equipment vendors and service providers that exert important influence on the market. Equipment providers such as GE and Siemens have been active acquirers of technology; integrators such as IBM and service providers such as Veolia are beginning to position themselves as critical partners to helping new ventures penetrate large municipal and industrial customers.
- Facing competition from well-financed, global competitors, innovators would benefit from test beds and incubators that allow them to more efficiently "even the playing field". This is yet another area where the EPA and Cincinnati region may have a significant role to play.

Background: Total Water Market

Satisfying water demand safely, efficiently, and cost effectively will undoubtedly be one of the great challenges of this century. While it may not yet be as central to public consciousness in the United States (U.S.) as energy conservation or materials recycling, access to a reliable water supply at a reasonable price is a fast growing area of concern across all water use markets – residential, commercial/industrial, and agricultural. The U.S. continues to lead the world in per capita water consumption and while the past decade has seen a decline in per capita water withdrawals, new industrial water use applications may begin to turn that demand curve back up.

In parallel to the potential for increased demand, the U.S. water infrastructure and supply ecosystem faces a host of emerging challenges. Among them are new contaminants entering the water supply and an aging distribution infrastructure that results in significant leakage and non-revenue water. At the same time, the economics of the water industry continue to be relatively opaque with the cost of delivered water far higher than actual prices paid by consumers. Finally, we see water at the center of various resource trade-off debates with energy, as well as with food/agriculture, resulting in commodity calculus scenarios that will stymie even the best-intentioned environmental economist.

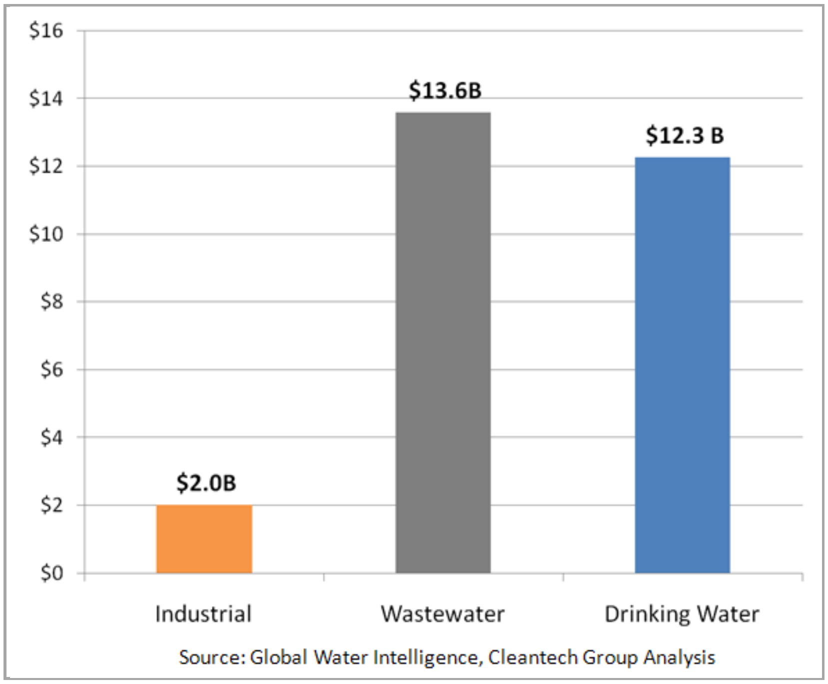
Water At The Nexus Of Trade-Off Debates



Despite these challenges, the U.S. water sector is a huge market opportunity for equipment vendors, technologists, service providers, and investors. **The entire U.S. water equipment market, across drinking water, wastewater, and industrial applications will total nearly $28 billion in spending in 2010**[1]. This total includes traditional pipes, valves, pumps, filtration and treatment equipment, along with an increasing amount of innovative technology from advanced membranes to water quality monitoring and management systems. The magnitude of this market size alone would lead most to believe that the water sector is a highly attractive market opportunity for innovators.

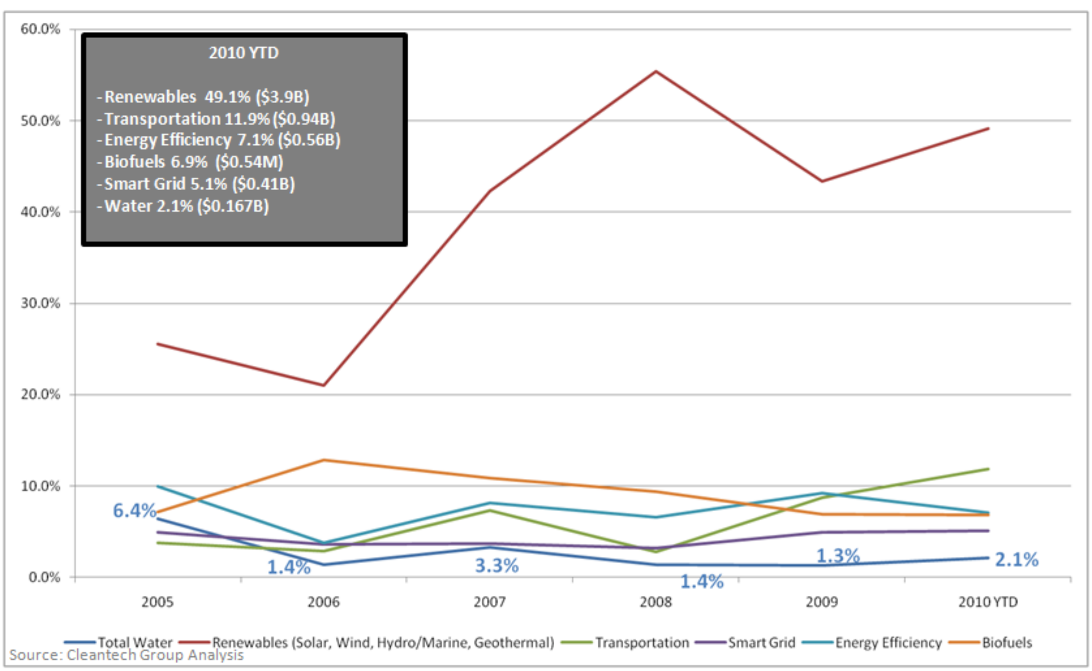
[1] Global Water Intelligence, Cleantech Group Analysis

Total U.S. Water Equipment Market



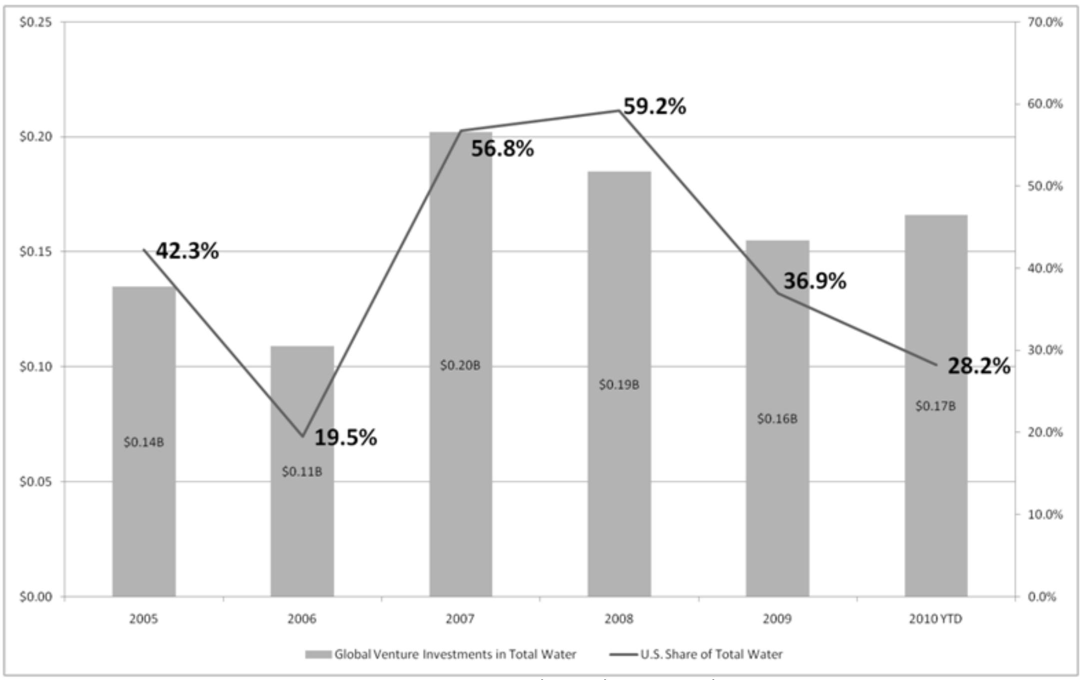
Analysis of venture capital dollars deployed in the sector, however, tells a very different story about investors' current faith in the ability of innovators to capitalize on this huge market opportunity.

Total Water Investments As a % Of Total Global Cleantech Venture Capital



As the Cleantech Group's global venture data illustrates, water technologies have only attracted between 1-3% of all venture investment; the majority of capital has been devoted to energy generation, transportation, and energy efficiency.   While 2010 will likely mark a new high for venture investments in the water sector – companies raised $166 million through the first three quarters of the year, just $15 million short of the 2007 record – the allocation of innovation capital for water technologies has been anemic in comparison to the water market opportunity and far lags the dollars that have flowed into other cleantech sectors.

Total Global Water Venture Investment and U.S. % Share of Investment

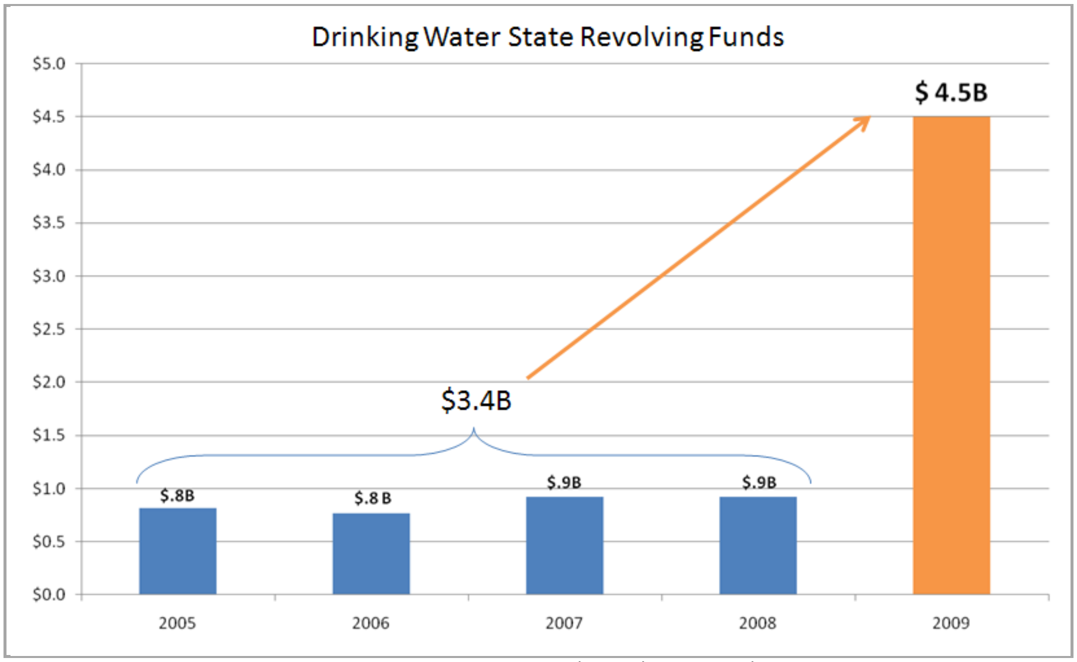


Source: Cleantech Group Analysis

This lack of capital is particularly acute in the U.S., which has captured 28% of total investment in 2010 and 37% of total investment in 2009 as opposed to its more typical 60% share of cleantech venture dollars in other sectors. Israel has been widely viewed as the global leader in water innovation and has seen the largest number of deals (by count) and is home to the most active water venture capital firm, Kinrot Ventures (now owned by AguAgro). There has been significant deal activity in the UK, as well as throughout the rest of Europe. Activity in Asia has primarily come out of China and Singapore. In addition to Kinrot, other firms including SAIL Venture Partners, Element Partners, Emerald Technology Ventures, Israel Cleantech Ventures, Virgin Green Fund, Chrysalix Venture Capital, and XPV Capital have all been amongst the most active firms in the world evaluating and investing in water technology deals.

While venture dollars have been relatively sparse, government has stepped into provide financing alternatives in certain areas of the water sector. The American Recovery and Reinvestment Act of 2009 (ARRA) provided stimulus funding that significantly boosted funds available via the State Drinking Water

Revolving Funds. In fact, 2009 allocations from these funds exceeded the four previous years combined total.



Source: EPA Data, Cleantech Group Analysis

A portion of these funds, 20%, was specifically earmarked to projects deemed "green" – including those focused on water conservation and efficiency. The vast majority, however, were awarded to critical "shovel-ready" infrastructure rehabilitation. There is no doubt that these projects were meritorious and many likely leveraged the best available technologies, but it would be inaccurate to claim that these funds directly stimulated new ventures. While somewhat limited, more accurate direct examples of government support of water innovation can be found in studying SBIR grants that have been made in the sector.

Taken together, the relative lack of private venture capital and the absence of significant, direct government support for water innovation, illustrate two large disconnects in the water sector:

(1) The disconnect between the size of the water market opportunity and breadth of fundamental challenges in the sector with the relative lack of venture investment in the industry. Typically, large market opportunities with significant technical and business problems to solve would quickly attract entrepreneurs and risk capital. As respected Silicon Valley venture capitalist Steve Jurveston said recently, "[water represents] probably the biggest mismatch between a screaming, enormous market and a lack of technology innovation I have ever seen."
(2) There is a disconnect between U.S. domestic innovation in the water sector vs. innovation in other domains. The U.S. has led the world in attracting institutional venture capital in nearly every sector except water.

Exploring these disconnects to understand the conditions necessary to catalyze investment in the water market requires deep sectoral analysis. It requires breaking down the total water market into its component parts, understanding the value chain of companies inhabiting each sub-sector, evaluating individual market sizes, assessing the competitive dynamics of the sub-sector, and diagnosing the impediments to investment. This report is focused on performing this type of analysis.

Background: Geographic Perspective On U.S. Water Equipment Market

Before diving into the drinking water sector however, it is instructive to provide guidance on the current geographic diversity of the U.S. water equipment sector. In looking at the water equipment market in the U.S., we catalogued over 480 leading equipment vendors involved in the total water market – from water treatment to distribution and systems monitoring, and finally wastewater treatment.   As our mapping illustrates, these firms were found in nearly all 50 states.

Mapping of U.S. Water Equipment Vendors

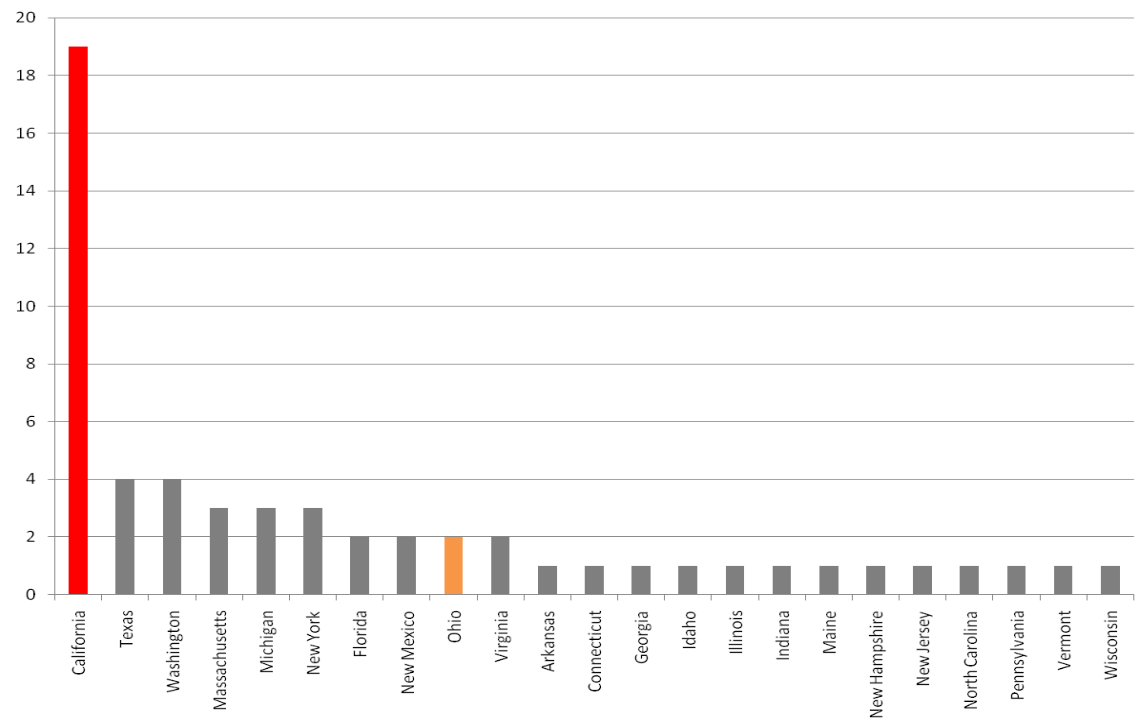
There has been some degree of clustering and a number of states do have a disproportionate number of water vendors. For purposes of this report and assessing Cincinnati's potential to cultivate water technology innovation, it worth noting that Ohio ranks toward the top of the list of states ranked by count of vendors. The greater Cincinnati region is also visible on the map above as one of the yellow clusters indicating intensity of companies.

Leading States By Count of All Water Equipment Vendors

State	Count
CA	76
IL	34
FL	33
PA	26
TX	26
NY	20
OH	19
MI	17
GA	15
MN	15
WI	15

Source: Cleantech Group Analysis

Distribution of Venture-Backed Water Equipment Companies



Source: Cleantech Group Analysis

This set of companies is predominantly, 78% (376 of 480), non-ventured back private firms many of whom have been in the business of providing basic equipment to water utilities for years, if not decades. There is a small set, 44, of larger, public companies, as well as a set of 60 venture-backed firms. For purposes of this report, we are most concerned with this latter 60, venture-backed innovators. As is demonstrated by the previous chart, the distribution of venture-backed companies is heavily weighted towards California – the state that has most traditionally garnered the vast majority of venture capital dollars. Ohio has two venture-backed companies in our data set. While California is positioned in its traditional spot atop this list, there is no secondary region that has distinguished itself, leaving what we believe is an open opportunity.

While we have seen certain U.S. states and cities mobilize to position themselves as innovation hubs for other cleantech sectors, for example, Philadelphia's push around building energy efficiency[2] , we have yet to see a concerted and sustained effort around water innovation. Milwaukee began an effort in 2008 around water innovation, but does not yet appear to have gained significant traction[3] and Fresno, CA has also been cited as a potential regional water innovation center.

Our geographic data on U.S. water technology vendors therefore has two key takeaways in placing Cincinnati in the context of the total water vendor market:

(1) When evaluating all vendors in our sample, there is significant geographic diversity, yet some states/regions do stand out. **Ohio ranks toward the top of this state list indicating a potential knowledge base of legacy vendors in the market**.

(2) Venture-backed firms remain highly concentrated in California with no secondary region currently vying strongly for second place. **This gap is also an opportunity as, to-date, no other region has made a successful, concerted effort to attract and cultivate venture-backed water innovators.**

With this macro, geographic opportunity in mind, we turn the remainder of this report to the investigation of the drinking water market.

Background: Scope & Methodology

As we outlined earlier, the total water equipment market is broadly comprised of three large sub-sectors: industrial, wastewater, and drinking water. **For purposes of limiting our scope, the remainder of this report will look exclusively at the market for drinking water innovation.** In focusing our lens, we must also acknowledge that there are not always entirely clean lines between these sub-sectors. Many technologies are applicable to more than one market area and because the water cycle is by its nature cyclical, choices made during wastewater treatment may ultimately impact drinking water treatment. Nonetheless, we hope to leverage a methodology in this report that could be used to explore the industrial and wastewater sectors in future analysis. In performing this analysis in the drinking water market, we aim to assist the EPA in:

1. Identifying new and innovative water treatment, transport, and handling strategies and technologies against the outlined drinking water challenge areas

[2] http://theenergycollective.com/greenskeptic/44209/philadelphia-innovation-cluster-seen-key-future
[3] http://www.jsonline.com/business/29473929.html

2. Understanding the needs and economic strengths of various industry segments and their ability to adopt the identified new and innovative drinking water technologies
3. Weighing the pros and cons of highly focused drinking water innovation versus total water management
4. Assessing Cincinnati area market for drinking water technologies
5. Assessing the impacts of current regulatory policy and possible policy reform on drinking water innovation.

In each of the following chapters, we will highlight each specific sub-segment of the drinking water technology market. Our analysis will:

(1) Explain some of the basic technology issues and market challenges that are being faced in this segment
(2) Place that segment in the context of both drinking water and total water management
(3) Present the current innovation market size for this segment
(4) Identify leading technology innovators mapped against drinking water challenge areas

Our report has been informed by significant secondary and primary market research. We have used the Cleantech Group's proprietary venture capital database and market research in the water sector as a basis for much of the data in this report. We have conducted extensive primary interviews across all segments of the water value chain to solicit feedback from stakeholders with differing vantage points.

Select List of Executives Providing Input

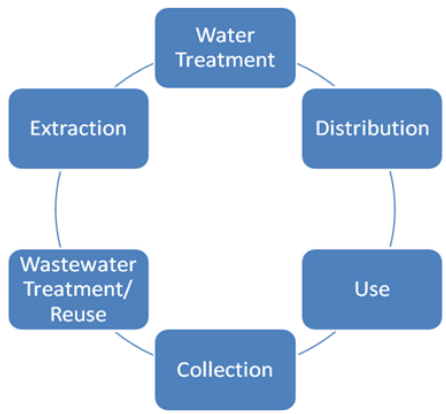
Utilities & Facilities Management	• **Veolia Environnement:** Bill Wescott, VP of North America Innovation • **American Water** Paul Gagliardo, Director of Innovation • **Global Water** Trevor Hill, Director of Innovation • **LADWP** Tom Erb, Director of Water Resources
Water Technology Vendors	• **IBM** Drew Clark, Partner – Water Technologies • **Siemens TTB** Lee Ng, Director Water Technologies, • **GE Water** Steve Kloos, Director Advanced Water Technologies
Engineering Firms	• **Kennedy/Jenks Consultants** Jean Debroux, Director Advanced Technologies Group
Venture Investors	• **SAIL Venture Partners** Hank Habicht , Partner • **XPV Capital** David Henderson, Principal • **Kinrot Ventures**

	Assaf Barnea, Partner

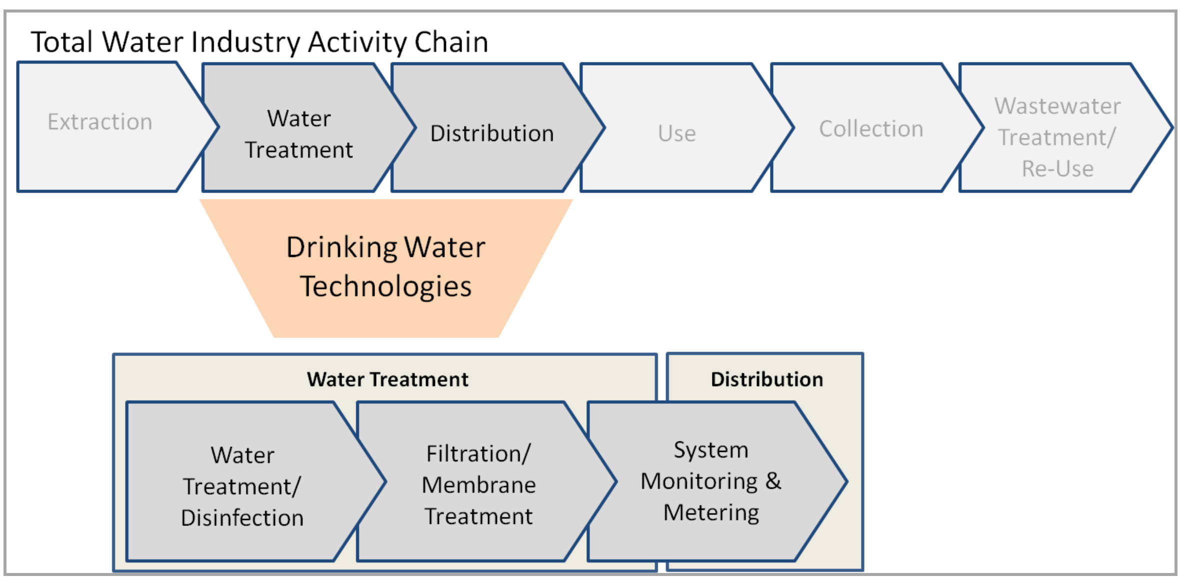
Background: Focus on Drinking Water

Water travels a complex path from extraction through treatment to distribution, use and re-use, and ultimately wastewater treatment, before being returned into the environment where this natural cycle begins again. Technology innovation influences every step of this water activity cycle and will play an increasingly important role in meeting the water challenges of the 21st century.

Total Water Cycle



Our analysis has led us to situate the drinking water innovation space within the water treatment and distribution portion of the water cycle.



Source: Cleantech Group Analysis

Within these two macro-activity areas, we have specifically identified three key segments that collectively make up what we define as the drinking water innovation landscape: Water Treatment/Disinfection, Filtration/ Membrane Treatment, and System Monitoring & Control. The remainder of this report will focus on dissecting the market opportunity, venture investments, and market dynamics that are shaping these three innovation areas.

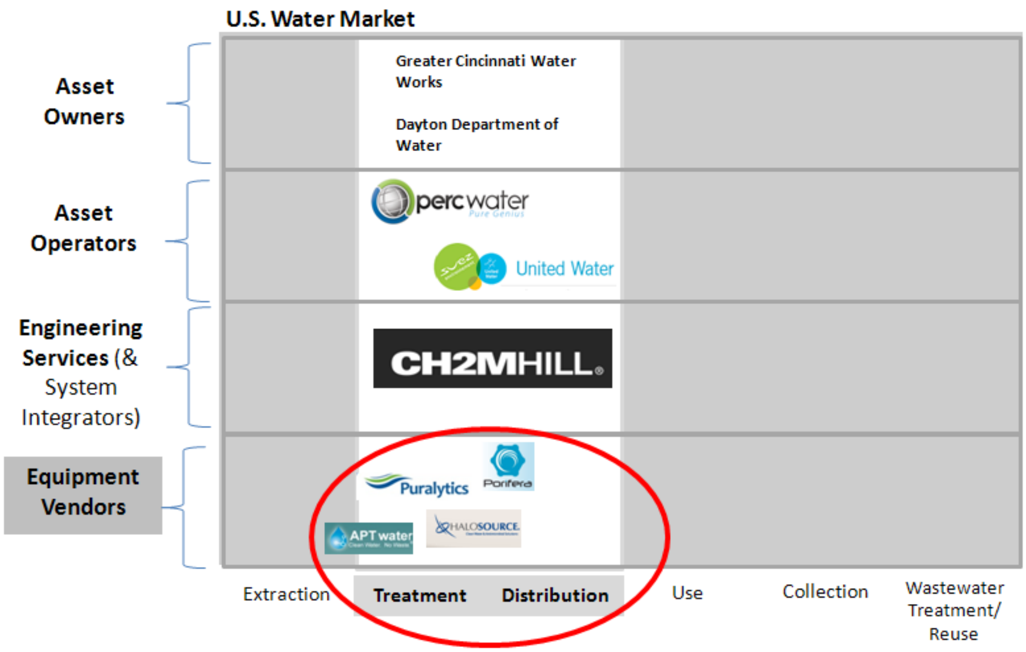
(1) Water Treatment/ Disinfection	(2) Filtration/ Membrane Treatment	(3) System Monitoring & Control
• Disinfection • Point-of-use • Other	• Membrane Treatment • Filtration • Membrane Desalination	• Automated Metering • Network and Process Management • Water Quality Management

It is important to note that our analysis of innovation is also specifically centered on the opportunity for new products and technologies (i.e. equipment). These technologies fit into a regulated, layered market landscape that has a variety of other key influencers and market participants. We will use the next section of our introduction to address some over-arching value chain and regulatory issues.

Focus on Drinking Water: Value Chain Drivers

As illustrated by the framework below, engineering, design, and construction firms, as well as asset owners and operators all play a role in the drinking water market value chain. These firms, and municipalities, can act to promote innovation or can be major obstacles to deployment of new technologies. Engineering firms play a critical role in evaluating the viability of technology choices for new build facilities and wield significant influence in supplier selection. Asset owners and private asset operators such as Veolia Water and United Water (Suez) can also play a lead role as service providers in vetting and deploying new technologies. While we will not cover these layers – engineering firms, asset operators, and asset owners – of the value chain directly, our analysis will attempt to call out how these firms can stimulate, or hinder, innovation.

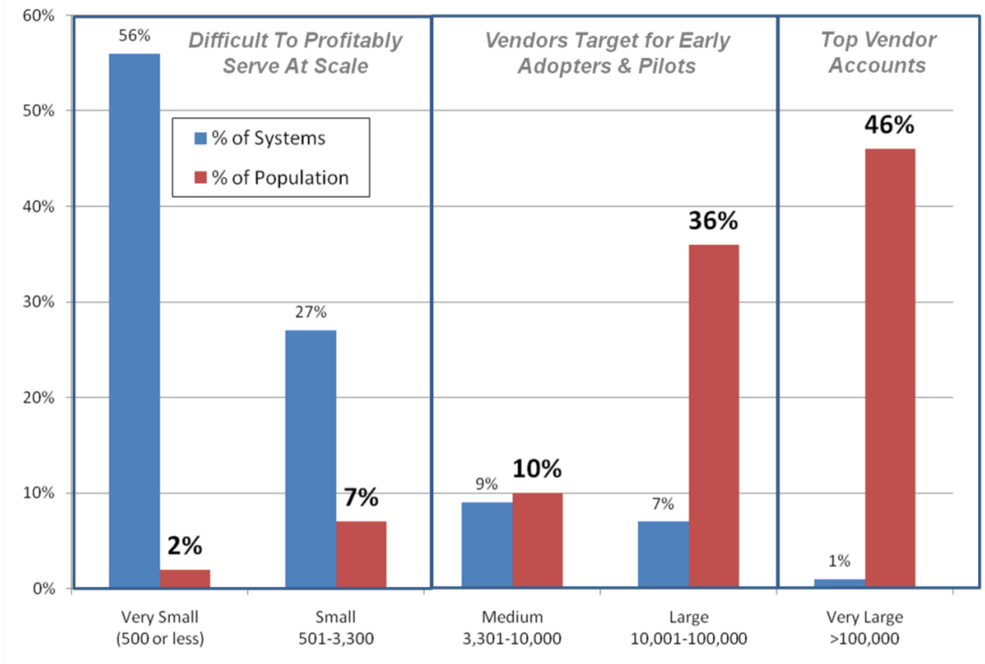
Drinking Water Market Value Chain: Focus on Equipment Vendors



Source: Cleantech Group Analysis

In particular when examining how vendors approach asset owners as potential customers, it is critical to consider the size of drinking water facilities and the dynamics of serving these facilities. The EPA categorizes drinking water systems into five categories by size from very small to very large. The following chart illustrates the markedly inverse relationship between population served and size of system for community drinking water systems (these systems cover 90%+ of America's population). As the EPA's 2009 data demonstrates, 82% of the population is covered by only 8% of the country's water systems (approximately 4,100 of 52,000 systems).[4]

Vendor Dynamics By Community Drinking Water Systems: By Size, % of Systems, % of Population



Source: 2009 EPA Factoids, Cleantech Group Analysis

Innovative new water companies are looking for customers that will have sufficient scale to drive revenue with a reasonable cost of sales and service. Consequently, it is very difficult for these firms to consider small or very small systems a potential market as the landscape is far too fragmented. Most innovators will look to larger systems to pilot technologies. Mid-size to large facilities are an ideal early adopter as they have sufficient scale for vendors to serve profitably, but may be able to move somewhat more nimbly than the largest of systems to adopt new technologies – though this is not uniformly the case. In general, for first adopters and pilots, early stage vendors will look for systems that meet a size threshold and that have the lowest sales friction. Finally, the ~400 very large systems that cover 46% of the population are key accounts for any vendor. They are the long term target market for any vendor hoping to become a major force in the drinking water market.

[4] http://water.epa.gov/scitech/datait/databases/drink/sdwisfed/upload/data_factoids_2009.pdf

Focus on Drinking Water: Regulation

Regulation has played a critical role in the protection of U.S. drinking water sources dating back to the enactment of the Clean Water Act of 1972 and the Safe Drinking Water Act of 1974. Because the public sector dominates ownership of U.S. water utilities, regulation and markets are closely intertwined. Regulatory policy drives drinking water markets in two key ways:

(1) **Regulation, coupled with enforcement, can drive markets.** Water systems tend to adopt innovation in direct response to new requirements. In many cases, there is little incentive for systems to act in the absence of both regulation and active enforcement. As a result of subsidies and a fixed tariff structure, municipal water utilities have a difficult time completing true cost benefit analyses of adopting new technologies. Instead, regulatory drivers dictate their adoption of new technologies in combination with available funding provided by the state and federal governments. For example, the best available technology standards put forth by the EPA, played a critical role in the creation and growth of the UV disinfection market in the U.S., where, previously, one did not exist. Market participants mentioned nutrient removal and real-time monitoring as areas where requirements could directly stimulate innovation and purchasing.

(2) **Regulation can influence the competitive landscape and available solutions.** Certification processes can directly determine which companies are viable or not. For example, one vendor, developing a monitoring technology capable of detecting metals in water sources in the parts per billion, described cost as its biggest challenge in attaining EPA certification as a best available technology (BAT). The company told us that the process would have required an allocation of $350,000 worth of staff hours to complete the certification. Consequently, the vendor has refocused its efforts on the process control markets for the chemicals and pharmaceuticals markets where there will be more predictable return on investment for the customer. This is an area where regional, EPA-supported test beds and incubators may be able to speed up the innovation process and may offer faster, more cost effective paths to market for new companies. The Cincinnati region seems well positioned to be a central location for this type of testing.

Despite the undeniable, successful impact that regulation has had in the U.S. in cleaning up and protecting water resources since the enactment of both the CWA and SDWA, challenges still exist. According to the 2004 EPA National Water Quality Inventory[5], 44% of assessed stream miles, 64% of assessed lake acres, and 30% of assessed bay and estuarine square miles were not clean enough to support uses such as fishing and swimming...top sources of impairment included atmospheric deposition, agriculture, hydrologic modifications, and unknown or unspecified sources."

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[5] See, The National Water Quality Inventory: Report to Congress: http://water.epa.gov/lawsregs/guidance/cwa/305b/upload/2009_01_22_305b_2004report_factsheet2004305b.pdf

Moreover, the drought ridden southeastern and southwestern states are facing challenges regarding the management of water resources to meet the demands of both growing urban populations and industrial users. For these reasons, it is critical for EPA to look into incentivizing and developing innovative water technologies within a broader, more holistic approach to water resource management.

According to several vendor interviews, the current regulatory structure is too compartmentalized and creates artificial boundaries where a unified approach to water resource management ought to exist. Regulation at the national, EPA level, is only part of the equation for any vendor that also must navigate state regulatory policies. Better coordination and clarity seems a frequent request from the commercial community.

For many vendors, municipal water utilities are the last customer segment to be addressed given its notoriously slow procurement process and certification processes. Engineering design firms are rightly beholden to the public health aspects of drinking water, which results in a preference for legacy, proven technologies.

As the EPA evaluates the role of regulation on innovation in the drinking water market, it is instructive to look at best practices around the world: Israel and Singapore have both leveraged regulation to pursue bold visions in the water sector and to strengthen their positions as global water leaders.

International Policies In Perspective

Israel	Singapore
Israel launched its Novel Efficiency Water Technologies program (NEWTech) in 2006. This program aims to build on Israel's experience in addressing its water scarcity problems, while advancing its water technology capability at an international level through strategic investments and allocation of substantial resources. NEWTech is led by the Ministry of Industry, Trade and Labor, which oversees a multi-ministerial steering committee. The committee is comprised of members from the Prime Minister's Office and the Ministries of Foreign Affairs, Finance, Science, National Infrastructure, and Environmental protection, as well as the Israel Water Authority, water and sewage program with an annual budget of $300 million. NEWTech has established 24 private and government funded water technology incubators that assist entrepreneurs in commercializing new technologies. These incubators are estimated to have attracted hundreds of millions of dollars worth of private investment. NEWTech has also invested in branding technologies within their incubator globally by establishing international partnerships and developing WATEC, an international exhibition and conference showcasing technologies, products and services. According to an interview with XPV capital, Israel's water industry exports doubled between 2005 and 2008, rising to $1.4 billion and are projected to be worth $2.5 billion by 2011.	In an effort to reduce Singapore's reliance of imported water from Malaysia, the country has strategically aligned economic, social and environmental requirements into a focused policy that prioritizes the water industry as a key economic growth area. Singapore has consolidated all water-related administrations under the Ministry of Environment and Water to streamline decision making. The main national water agency, the Public Utilities Board (PUB), has become a statutory board member and has responsibility for managing all comprehensive water related matters. The PUB is not only a testing and demonstration site but as well as facilitator of research and technology development. Tax breaks and other financial incentives have attracted the interest of multi-national corporations in Singapore's water industry. In 2006, GE built its R&D center in Singapore, which resulted in the employment of 100 top-tier researchers. Siemens Water Technologies similarly opened its global R&D center in Singapore in 2008. The center collaborates with Singapore's PUB, universities in environmental authorities on water and wastewater projects. And finally, engineering consulting firm CH2M HILL established its regional headquarters in Singapore in 2006, which now employees more than 350 individuals

Focus on Drinking Water: Total Water Management

Israel and Singapore's focus on growing domestic water resources is consistent with other regional initiatives to pursue Total Water Management (TWM) strategies. While the focus of this report is limited to drinking water, it is important to acknowledge its place in a potentially broader TWM framework.

Total Water Management (TWM) is defined as the stewardship of water resources for the greatest good of society and the environment[6]. Many water scarce regions of the world are adopting approaches that are very similar in principle for managing their water resources. A TWM approach is designed to integrate and address the major water management problems facing the society. These water management problems can generally be categorized into one of the following three:

1) **Water supply problem** – How to sustain and adequately expand high-quality water resource(s) to meet increasing customer demand(s)?
2) **Water quality problem** – How to minimize the impacts of contamination from human activity and development?
3) **Environmental problem** – How to make water management decisions that result in positive changes to the surrounding environment (e.g., hydrologic modification)?

TWM allows for a "holistic" approach where region-specific disparities can be aligned and addressed in a comprehensive manner and allows for some variability rather than a "one size fits all" approach.

An often cited example that follows a TWM approach is the European Union (EU) Directive 2000/60/EC (issued on October 23, 2000). This directive establishes a framework for community action in the field of water policy and is commonly referred to as the EU Water Framework Directive (WFD). The EU WFD is organized to protect and manage water resources at the river basin level. The implementation of the WFD is expected to result in achieving significant improvements in the quality of surface water, groundwater, transition water (estuaries), coastal waters, and optimize the overall water use throughout the EU.

In the U.S., development of such a high-level of "command-and-control" framework and shared governance approach would require collaboration and agreement(s) between a multitude of federal, state and local agencies. For example, the following nine (9) federal agencies through various laws and regulations control the key foundations for implementing a TWM approach: U.S. Environmental Protection Agency (EPA), Food and Drug Administration (FDA), U.S. Fish and Wildlife Service (FWS), Federal Energy Regulation Commission (FERC), U.S. Army Core of Engineers (USACE), U.S. Geological Service (USGS), U.S. Department of Agriculture (USDA), U.S. Bureau of Reclamation, and Federal Emergency Management Agency (FEMA).

In addition to these federal regulating authorities, there are numerous authorizations, appropriations, treaties, interstate compacts, state, tribal, and local laws the also impact the process of TWM. In spite of the institutional and political challenges faced by these regulating authorities for adopting a TWM

[6] AwwaRF, 1996

process, some agencies are innovating by looking at providing incentives for conservation and best management practices (BMPs), allowing for alternate assessment methodologies, and educating the consumer. A few examples of these innovations are: encouraging communities to landscape and garden in ways that reduce or eliminate the need for supplemental irrigation (Xeriscaping), use of rate structures and automated metering to reduce water consumption, use of triple bottom line (TBL) reporting – where environmental, social and economic impacts are assessed collectively.

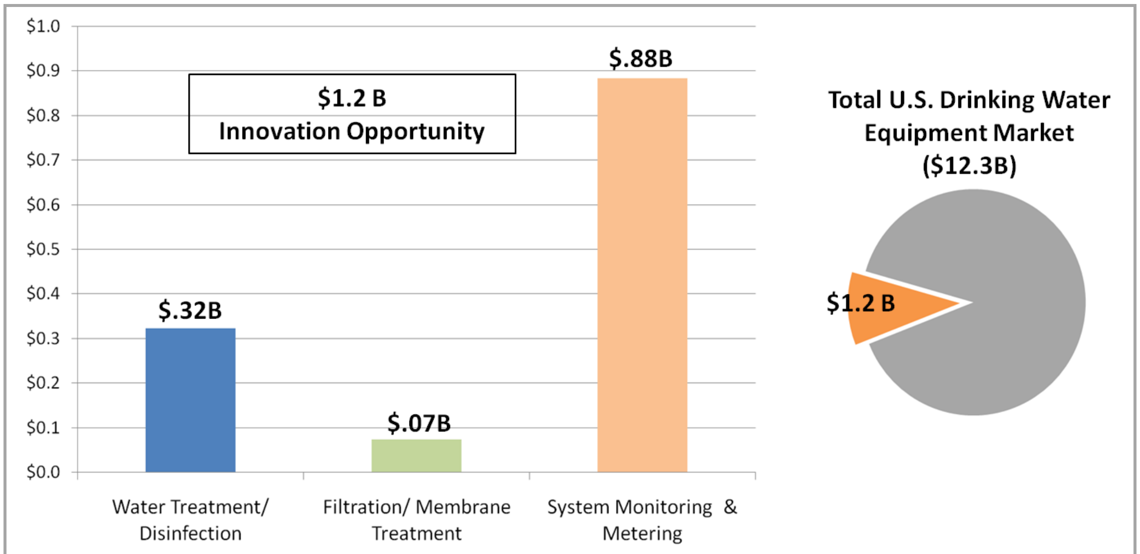
Conceptually, any commercial innovation within the drinking water category would be designed to treat water in a more energy and/or time efficient manner, to more effectively remove and/or recover the contaminant(s) or compound(s) of concern, or to more efficiently distribute water thereby promoting conservation. All of these water technology innovations are essentially meeting the definition of TWM process. Therefore, by design these innovative products will appeal to all market sectors participating in the water cycle even if a comprehensive TWM process is not in place to encourage these types of innovations.

As we will discover in our investigation of innovative vendors in the sector, many have technologies that can crossover between water markets – i.e. wastewater technologies applicable to drinking water, or industrial water solutions with applications for drinking water. For example, APTWater, which we will cover later in this report, has cross-application in both wastewater and drinking water markets. A company such as American Micro Detection Systems illustrates how technology addressing water challenges in the chemicals and pharmaceuticals industry can also be leveraged for drinking water applications.

Despite this natural crossover, a sound TWM process can increase the rate of adoption of any innovative technologies across the market sectors.

Focus on Drinking Water: Market Size and Analysis

Even as we take into account all of these value chain, regulatory, and total water management dynamics and begin to narrow our lens to focus precisely on the equipment opportunity within our three key drinking water segments, we find a significant market opportunity. **Our analysis indicates that approximately $1.2 billion will be spent on the three major drinking water innovation product categories in the U.S. in 2010**.

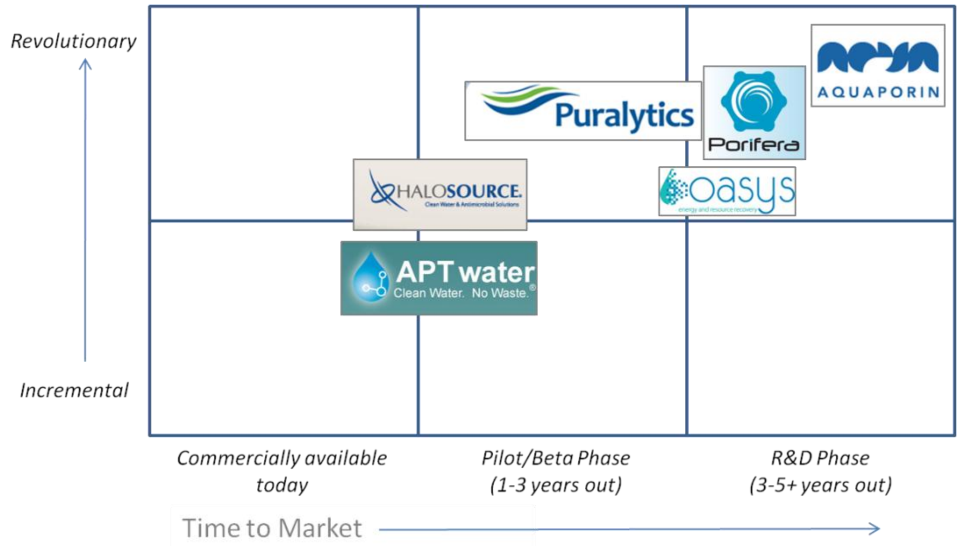


Source: Global Water Intelligence, Cleantech Group Analysis

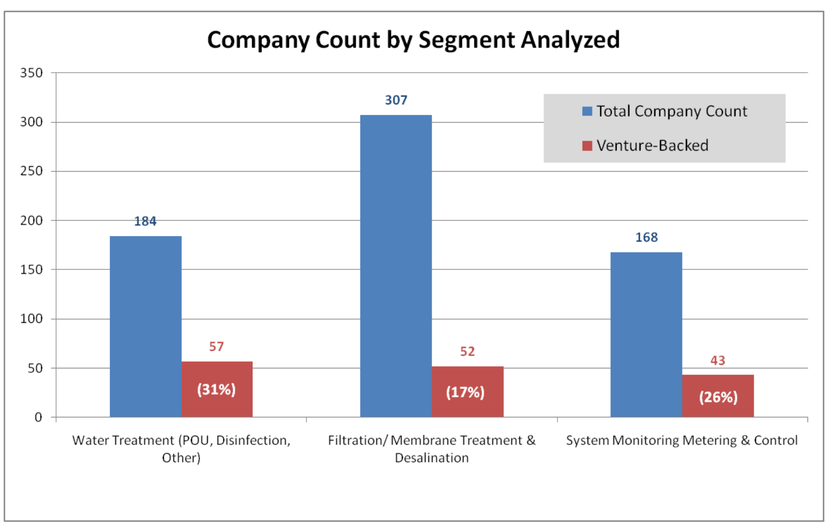
This analysis is derived from information gleaned from vendor interviews, third party research firms and our own calculations and should serve as a foundation for dialogue, critique, and for continued industry discussion. This estimate is approximately 10% of the overall $12.3B market for all drinking water equipment. We expect that this portion of the market classified as "innovation" will increase as a percentage of total equipment spent as the market rotates to place a greater emphasis on advanced solutions.

The potential for this future market growth becomes evident when we map some of the drinking water sector's leading venture-backed innovators on our Market Anticipation Matrix. We find that many of the leading ideas in the market, those with "revolutionary" potential, are also those with longer predicted times to market - more than three years away from general, commercial availability. While relatively long time-to-market has been a venture dynamic in many other cleantech sectors – investments in technologies such as solar, carbon sequestration, and biofuels also have long time horizons – advances in water technologies do tend to have markedly long development cycles and pilot phases. While this gives reason to be optimistic about technologies in current incubation stages, this long time-to-market has been a chief concern amongst venture investors that are more comfortable seeing shorter payback periods. It is clear that the water sector will require a great level of patience from both investors and entrepreneurs.

Cleantech Group Market Anticipation Matrix: Select Water Innovators



The following chapters will explore the innovative companies attempting to overcome these long time markets, complex value chain dynamics, and capital constrained environment to bring new technologies to market in each of our three drinking water innovation segments. Our work categorized over 800 companies working across these segments, yet we will focus most of our attention on the private, venture backed vendors given the scope of this work. A database of all these vendors is available as a companion to this report.



Source: Cleantech Group Analysis

As noted, our report has focused primarily on the water equipment and system monitoring product vendors. While engineering and operator services represent a massive and very important portion of the water market, we have not catalogued vendors involved with such services. Secondly, we have not included vendors involved with the consumables or chemicals market related to water treatment. And finally, while traditional pipes, pumps and valves currently account for the largest share of the drinking water equipment market, we omitted vendors of solely traditional technology in our analysis.

I. Water Treatment/ Disinfection Technologies

Key Takeaways

- Disinfection technology applications for drinking water represent a significant market opportunity.
- Many disinfection technologies can also be applied to industrial water and municipal wastewater treatment applications
- Private companies in this segment illustrate the difficulty of growing to scale for water technology providers. Many of these companies do not fit a classic model for either venture investors or larger, private equity firms.
- Large, legacy vendors have built market dominance through a series of strategic acquisitions; the disinfection market continues to be populated by both pure-play water companies and these multi-industry giants though suggesting the possibility of further consolidation.

Key Vendors

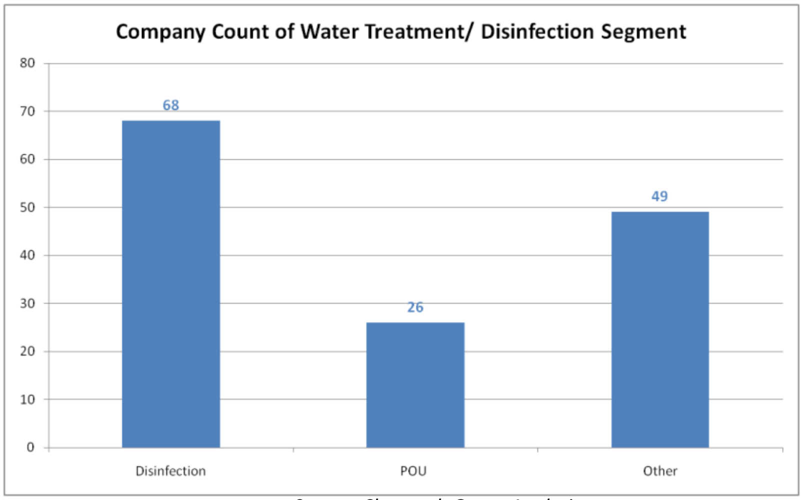
• ITT: WEDECO	• BWT	• APTWater
• Siemens Water Technologies	• Atlantium	• Puralytics
• Severn Trent Services	• ProMinent	• AquaPure
• Degremont Technologies - Ozonia	• Fuji	• HaloSource
• Trojan Technologies	• Mitsubishi Electric Power	• Pasteurization Technology Group

Defining clear, simple product categories for drinking water technologies can be a difficult challenge. This is particularly true for water treatment technologies, which are minutely fragmented and include treatment methods ranging from activated carbon fabric, electro-coagulation, photo-catalytic processes, ion-exchange and thermal evaporation. Consequently, product categorization in water treatment will be imperfect, but will help us draw distinctions in the sector. We have included the following technologies in the Water Treatment/ Disinfection segment:

(1) **Disinfection**
(2) **Point-of-use** (POU)
(3) **Other technologies**

Our analysis indicates that companies concerned with disinfection account for almost half (48%) of this segment. There is a fine line of distinction between disinfection and POU, since the latter is an application and can include other types of technologies like membrane or adsorption technologies. Other technologies include the various sorption technologies including ion exchange, activated alumina and activated carbon. Because we (1) see a concentration of innovation in such technologies, and (2) disinfection represents a large market opportunity, this chapter will focus primarily on the disinfection market.

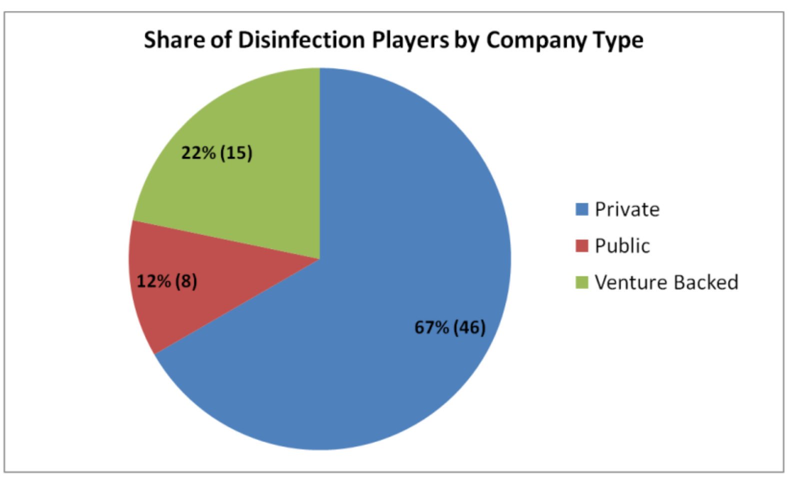
W**e estimate total U.S. spending across these Water Treatment/ Disinfection categories will be approximately $0.32 billion in 2010**. This estimate is based on analysis of third party data, interviews, and our own internal analysis.



Source: Cleantech Group Analysis

The primary reason for disinfection technologies' significant market opportunity is due to its various applications. Not only is disinfection the key aspect of treatment for drinking water applications, it is equally important in myriad industrial process water and wastewater as well as municipal wastewater applications.

Our analysis indicates that 72% (49) of the disinfection companies that we catalogued are private, 22% (15) are venture-backed and 6% (4) are public. Many private players are often in the difficult position of sitting in between the interest of the venture capital and private equity (PE) community. Few private companies are large and profitable enough to attract PE, while many early stage companies are not equipped with cutting edge technology or intellectual property-centric offerings to excite the VC community.

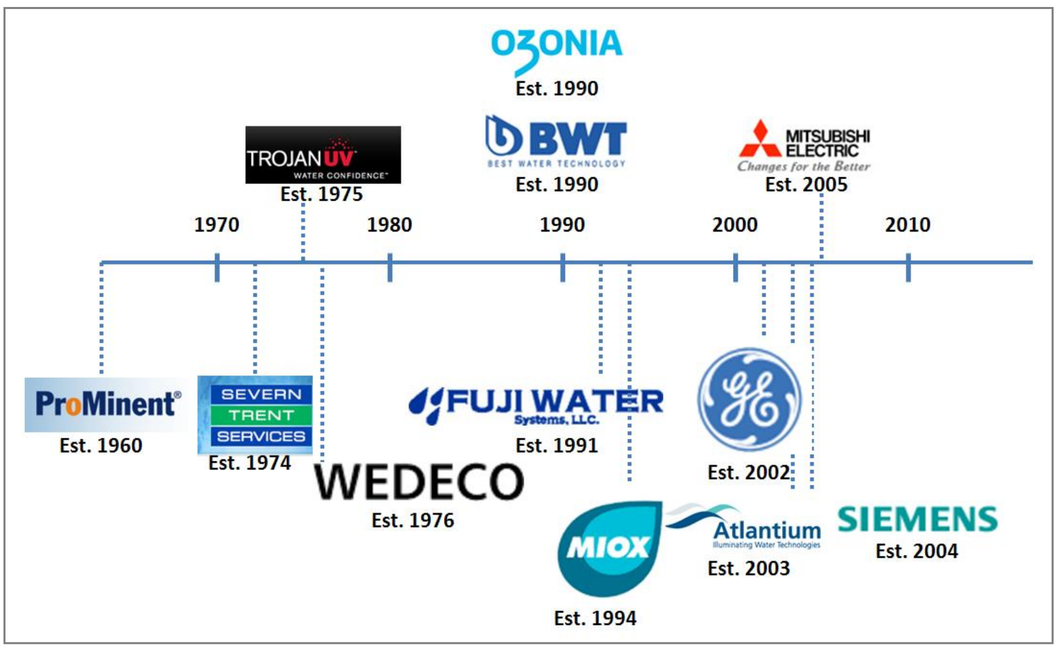


Source: Cleantech Group Analysis

The multitude of private players illustrates the elusiveness of scale for water technology companies combined with the overall dilemma that water technology development may not always fit the venture capital business model. For one, a key to the success of any water technology company is the ability to build a list of referenceable clients. To do so, requires both increasing customer access and working capital – both of these are significant challenges for vendors without ready access to growth capital. Secondly, some water technology innovation is an incremental process improvement via engineering design that could include a hybrid of existing technologies, which could potentially be difficult to patent – a very difficult proposition for the venture capital model.

Of the twelve established players in the disinfection market, two were venture-backed while the remaining are public companies. These market leaders are older, established companies that grew as a result of investing through long technology development cycles, developing referenceable projects, and then for some, a series of strategic acquisitions to expand geographic footprint and technological capabilities.

Evolution of the Disinfection Market



Source: Cleantech Group Analysis

There are three disinfection methods that currently dominate the market today: chlorination, ozonation and ultraviolet (UV) radiation. The majority of competition is occurring between UV radiation and ozone technologies and established players within disinfection claim market share based on some combination of these methods.

While conventional chlorine disinfection is increasingly losing market share to advanced ozone or UV disinfection technologies, chlorine is expected to maintain some presence in the market due to its disinfection residual capability critical to distribution systems. As the table below summarizes, UV disinfection has the key advantage of being a by-products-free physical process with low chemical management costs and safety risk.

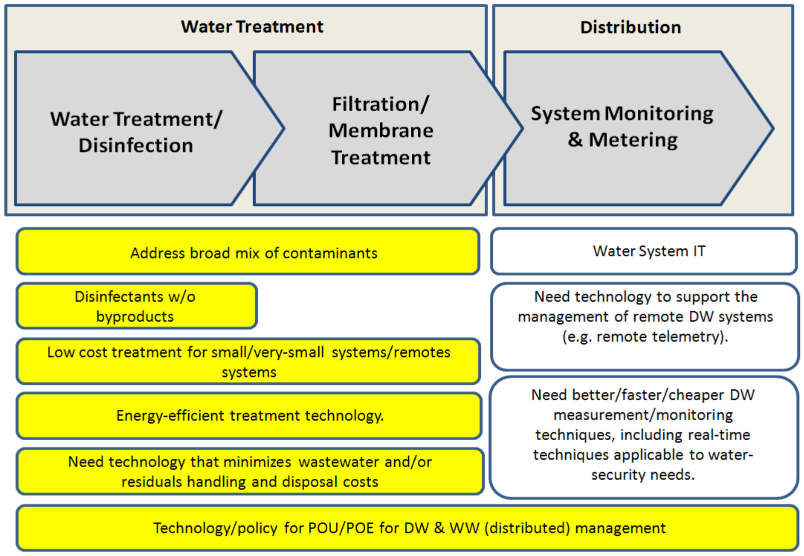
Meanwhile, ozone disinfection is more costly in terms of capital and operational costs but provides the added benefit of eliminating odor, color and taste – making it a desirable disinfection method for the beverage industry.

Disinfection Method	How it works	Pros	Cons
Chlorine	Chlorine gas, sodium or calcium hypochlorite is added to water and within 20 minutes kills bacteria, viruses and water-borne pathogens.	• Not only disinfects but also remains at a residual level in the water, preventing re-infection by viruses or bacteria during transport, storage and distribution. • Cost-effectiveness	• Ineffective at deactivating giardia and cryptosporidium. • Produces disinfection by-products
Ultraviolet (UV) Radiation	Ultraviolet light is exposed to microbes causing photochemical damage that halts cell synthesis and division.	• Cost-effectiveness • Minimal by-products	• Photoreactivation and dark repair can reverse the damage of UV Radiation.
Ozone	Ozone, a colorless and unstable gas, is generated by air discharge, electro analysis and ultraviolet light radiation to kill bacteria and viruses.	• Short reaction time • Requires no chemicals • Oxidizes iron and manganese • Destroys and removes algae • Aid coagulation	• Cost • Produces disinfection by-products • Toxicity

Vendor Landscape: Disinfection Methods

Source: Cleantech Group Analysis

Within the context of these disinfection challenges, the U.S. EPA has outlined specific drinking water challenge areas.



In the following sections, we will:

(1) Outline the key drivers of the drinking water challenge areas
(2) Address each drinking water challenge area as it relates to the early-stage innovation that we have identified.

Below are the ten drinking water challenge areas outlined by the EPA:

(1) Need innovative drinking water and water reuse treatment technologies to address health risks posed by mixtures of a broad array of contaminants, including emerging (currently unregulated) contaminants.
(2) Need alternative disinfectants and treatment technologies that effectively control pathogens without formation of disinfection by-products.
(3) Need cost-effective DW/WR treatment technology for small/very-small systems and remote systems.
(4) Need technology that minimizes wastewater and/or residuals handling and disposal costs.
(5) Need more energy-efficient technology
(6) Need effective/useful information technology infrastructure to support decision making that improves the safety and sustainability of water systems for Total Water Management.
(7) Need technology to address water supply (quality/quantity) challenges associated with demographic and population change impacts.
(8) Need DW/WR point-of-use/point-of-entry (POU/POE) treatment technologies for operational regulatory, and management approaches (need both a technical solution and policy incentives).
(9) Need monitoring and control (MC) technologies to support the management and regulatory compliance of remote DW/WR systems.
(10) Need better/faster/cheaper DW/WR measurement/monitoring techniques, including real-time techniques applicable to water-security needs.

Drinking Water Challenge Area Drivers

The 1996 Milwaukee Wisconsin cryptosporidium outbreak that caused the death of at least 100 people, catalyzed the adoption of ultraviolet radiation as an alternative to chlorine disinfection. The outbreak revealed chlorine disinfection was ineffective at deactivating both cryptosporidium and giardia. Indeed, the desire to avoid such public health issues for drinking water applications similarly incentivize industries like food and beverage to mitigate reputational and litigation risks associated with contaminated products. Ultrapure, disinfected water is fundamental to their business.

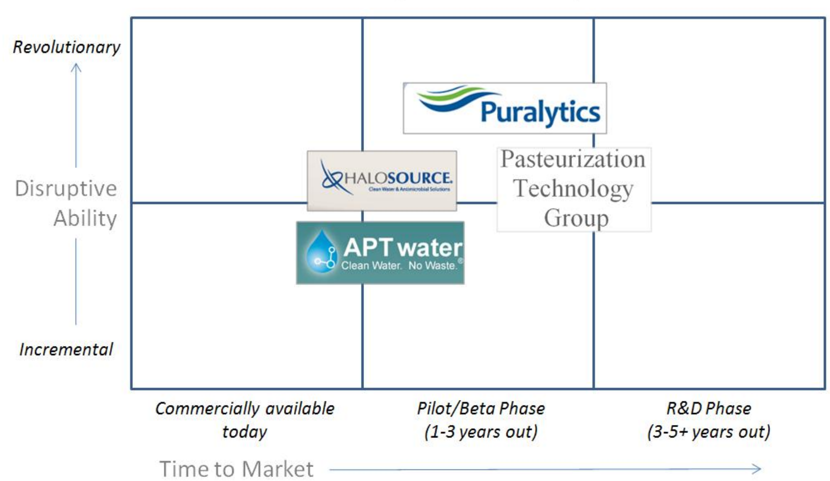
Meanwhile, as our understanding of the chemistry of water contamination expands and as analytical technologies improve, we continue to discover more compounds of potential concern to human health. Particular emerging contaminants, including pharmaceutical and personal care by-products and endocrine-disrupting compounds, have been detected in low levels in the environment not only in the U.S. but across the globe, according to various studies.[7]

Because chemical species in water can often react with a disinfectant to form a disinfection by-product (DBP) – carcinogenic, mutagenic compounds capable of causing birth defects are of increasing concern. Chlorinated DBPs include trihalomethanes and haloacetic acids. Ozone disinfection, on the other hand, transforms large organic polymers to smaller organic molecules, which results in nutrients that encourage biofilm growth in distribution lines. Finally, ozone disinfection also converts bromide to bromate, a regulated compound.

Emerging Innovation

Against this backdrop, innovators are increasingly concerned with developing alternative disinfection methods that not only control pathogens, but do so with low capital & operational costs while addressing a wide array of contaminants and reducing disinfection by-products.

Cleantech Group Market Anticipation Matrix



We have developed an extensive data set of venture-backed innovators in the space.

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[7] See, http://epa.gov/waterscience/ppcp/studies/results.html

Recently Funded Water Treatment/Disinfection Companies (Funding in 2009 or 2010)

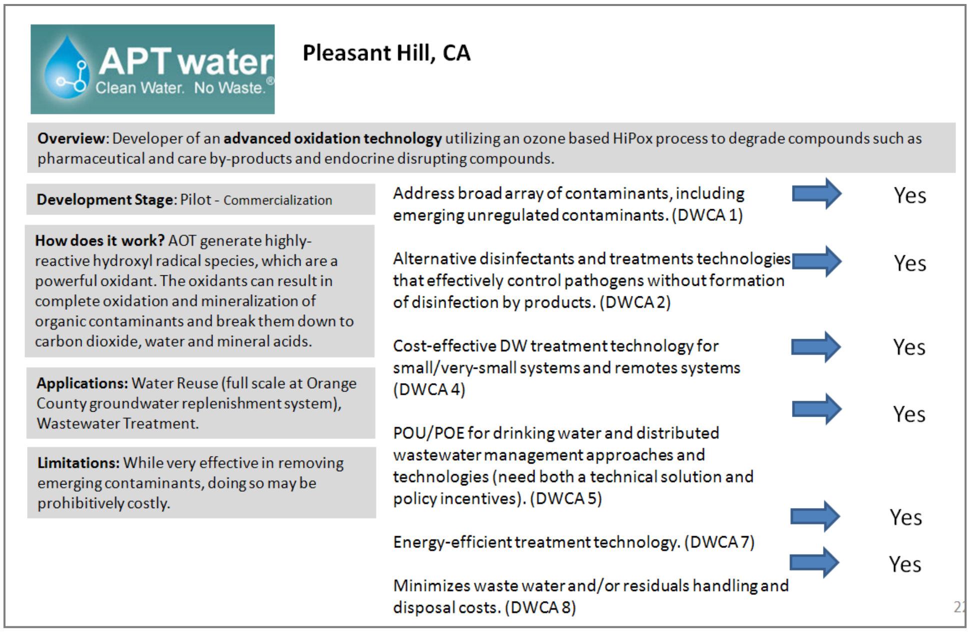
Company	Country	Description	Most Recent Capital Raise
WaterHealth International Inc.	USA	Developer of water purification and disinfection technology for areas with little or no access to clean and affordable water.	$22,100,000
Quench	USA	Maker and distributor of water purification 'point-of-use' coolers that utilize ultraviolet light technology and avoid the waste of bottled water and traditional cooler systems.	$13,000,000
Aqua Designs Pvt. Ltd.	India	Aqua Designs is a Total Water Management Engineering Company with engineering capabilities to undertake and execute turnkey solutions for water and waste water management.	$12,000,000
Ningbo Qinyuan Group	China	A developer of water treatment equipment for drinking water machines.	$12,000,000
HaloSource, Inc.	USA	Developer of antimicrobial coatings and drinking water treatment products.	$10,000,000
WaterHealth International Inc.	USA	Developer of water purification and disinfection technology for areas with little or no access to clean and affordable water.	$10,000,000
Clean Filtration Technologies	USA	Developer of a self-cleaning, maintenance-free metal membrane used to process waste water and produce clean, drinking water.	$5,500,000
Activeion	USA	Developer of a portable cleaning tool that converts tap water into a powerful cleaner on demand, eliminating the need for repeat purchases of toxic, general-purpose cleaning chemicals.	$5,000,000
Claranor	France	Developers of low-energy, zero water consumption pulsed light desinfectant technology. Can be used for water treatment as well as other non-liquid products.	$3,500,000
WaterHealth India Private Limited	India	WHI's unique and creative combination of break-through technology and innovative business models enables the delivery of highly affordable, clean water.	$2,660,998
Hydro-Photon, Inc.	USA	Developer of a handheld device - Steripen - that utilizes ultraviolet light to purify water.	$2,000,000
Microvi Biotech	USA	Developer of biotechnology based water treatment solutions that are capable of destroying a wide array of pollutants in water.	$1,000,000

Source: Cleantech Group Analysis

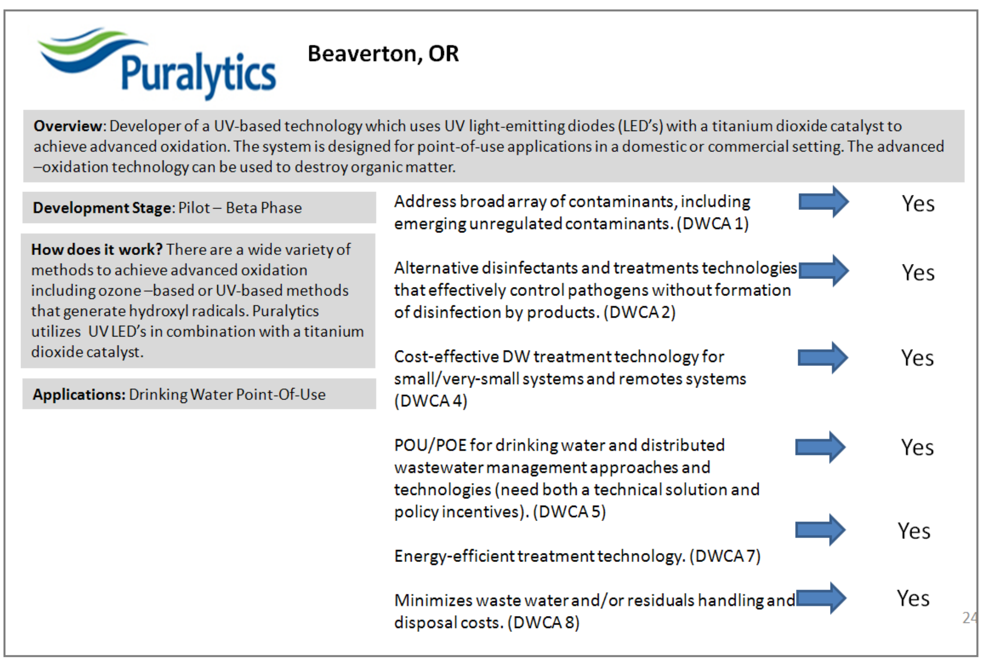
To illustrate innovators in this space, we have identified four key vendors that are offering disinfection solutions:

Pleasant Hill, California-based **APT Water**, is developing an advanced oxidation technology utilizing an ozone based HiPox process to degrade compounds such as pharmaceutical and personal care by-products and endocrine disrupting compounds. Advanced oxidation technologies generate highly reactive hydroxyl radical species, which are a powerful oxidant. The oxidants can result in complete oxidation and mineralization of organic contaminants and break them down to carbon dioxide, water and mineral acids.

The company is currently at a piloting-commercialization development stage with a full scale water reuse installation at Orange County's groundwater replenishment system. While the technology is very effective in removing emerging contaminants, doing so may be prohibitively costly.



Beaverton, Oregon based **Puralytics** is developing a UV-based technology which utilizes UV light-emitting diodes (LED's) with a titanium dioxide catalyst to achieve advanced oxidation. The systems is designed for point-of-use applications in a domestic or commercial setting. The advanced oxidation technology can be used to destroy organic matter.



While there are a wide variety of methods to achieve advanced oxidation including ozone-based or UV-based methods that generate hydroxyl radicals, the company utilizes an innovative combination of UV LED's and a titanium dioxide catalyst. The company is still at a pilot-beta phase.

Bothell, Washington-based **HaloSource** is developing a bromine based disinfection technology: N-halamines and Chitosan utilizing chlorine and bromine for drinking water and antimicrobial treatment. Bromine belongs to the halogen chemical group, which are strong oxidizing agents and could be used to disinfect water and inactive pathogens.

HALOSOURCE. Clean Water & Antimicrobial Solutions

Bothell, WA

Overview: Developer of a two core technologies: N-halamines and Chitosan utilizng chlorine and bromine for drinking water and antimicrobial treatment.

Development Stage: Pilot - Commercialization

How does it work? Bromine belongs to a chemical group known as Halogens, which are strong oxidizing agents and could be used to disinfect water and inactive pathogens.

Applications: Drinking Water Point-Of-Use

Address broad array of contaminants, including emerging unregulated contaminants. (DWCA 1)	Yes
Alternative disinfectants and treatments technologies that effectively control pathogens without formation of disinfection by products. (DWCA 2)	Yes
Cost-effective DW treatment technology for small/very-small systems and remotes systems (DWCA 4)	Yes
POU/POE for drinking water and distributed wastewater management approaches and technologies (need both a technical solution and policy incentives). (DWCA 5)	Yes
Energy-efficient treatment technology. (DWCA 7)	Yes
Minimizes waste water and/or residuals handling and disposal costs. (DWCA 8)	Yes

San Leandro, California based **Pasteurization Technology Group** is developing a technology that utilizes waste heat to provide disinfection.

Pasteurization Technology Group

San Leandro, CA

Overview: Developer of a technology that utilizes waste heat to provide wastewater disinfection.

Development Stage: Early Commercial

How does it work? A patented air-to-water heat exchanger which can take waste heat from the exhaust gases of a combined heat and power (CHP) system, or any other source of waste heat, to heat water up to 80 degrees celsius.

Applications: Wastewater, treatment, water reuse.

Limitations: While very effective in removing emerging contaminants, doing so may be prohibitively costly.

Address broad array of contaminants, including emerging unregulated contaminants. (DWCA 1)	Yes
Alternative disinfectants and treatments technologies that effectively control pathogens without formation of disinfection by products. (DWCA 2)	Yes
Cost-effective DW treatment technology for small/very-small systems and remotes systems (DWCA 4)	Yes
POU/POE for drinking water and distributed wastewater management approaches and technologies (need both a technical solution and policy incentives). (DWCA 5)	Yes
Energy-efficient treatment technology. (DWCA 7)	Yes
Minimizes waste water and/or residuals handling and disposal costs. (DWCA 8)	Yes

The company has a patented air-to-water heat exchanger which can take waste heat from the exhaust gases of a combined heat and power (CHP) system, or any other source of waste heat to heat up water up to 80 degrees Celsius. The technology is in an early commercialization development stage.

II. Filtration/ Membrane Treatment

Key Takeaways

- New membrane technologies have long development cycles and often require upwards of five years to complete development and piloting cycles.
- Reverse osmosis (RO) membranes have succeeded in reducing the energy requirements of desalination plants and have broader applicability in ultrapure industrial process water.
- Low pressure ultrafiltration and microfiltration membranes provide a simple means of guaranteeing not only safe drinking water but high quality treated effluent and industrial process water.
- The optimization of RO desalination systems is dependent on the innovation within the core subsystems: (1) pretreatment (2) RO membrane units and (3) energy recovery devices.

Key Vendors

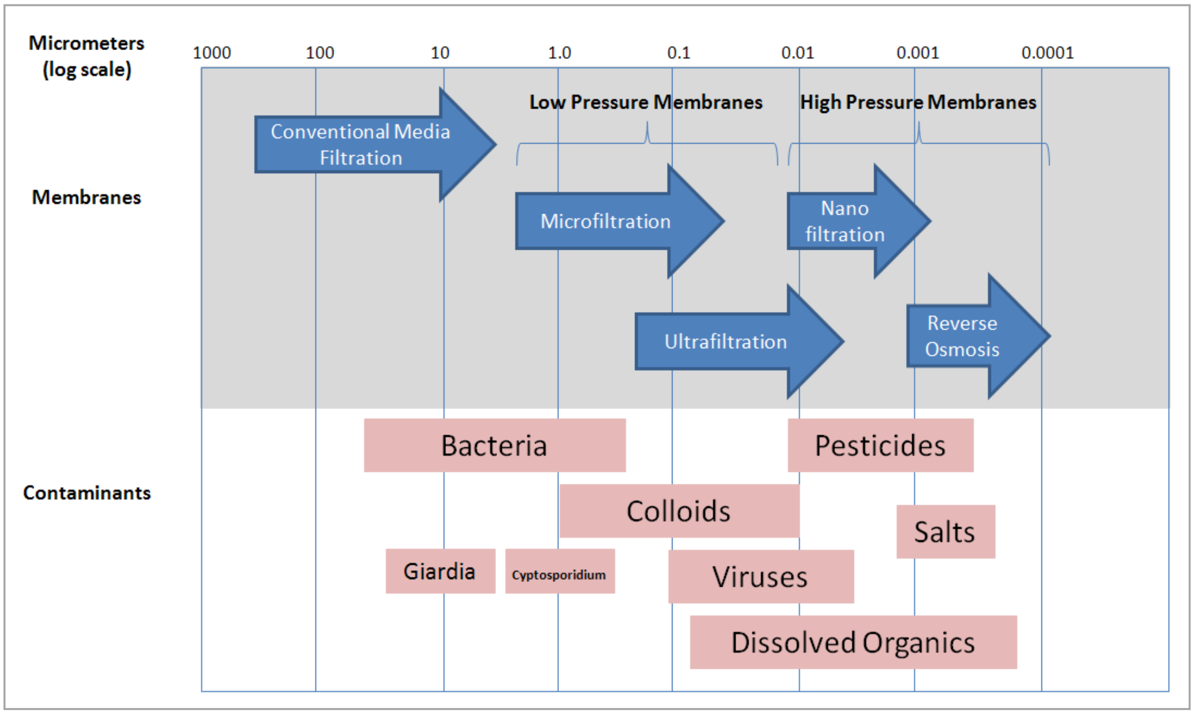
- Dow Water & Process Solutions
- Hydaranautics
- Toray
- Saehan CSM
- Toyobo
- Koch Membrane Systems
- Pall – Asahi Kasei
- GE - Zenon
- Aqualyng
- Inge
- Norit X-Flow
- Siemens - Memcor
- Porifera
- Oasys
- Aquaporin
- NanoH20

While evaporation has served as an important method for removing dissolved solids out of water for centuries, the development of the reverse osmosis (RO) membrane in 1965 began a fundamental disruption of the thermal desalination market by drastically reducing energy costs.

Since this breakthrough, there has been tremendous interest in membrane technology that not only focuses on salt separation using high pressure RO and nanofiltration (NF) membranes but also encompasses the emergence of low pressure membranes including ultrafiltration (UF) and microfiltration (MF) membranes. Both classes of membranes are offering advanced treatment methods that could provide safe drinking water supply, provide high quality treated effluent for reuse and serve a number of industrial applications.

The Filtration/ Membrane Treatment segment is comprised of vendors concerned with the improvement of conventional media filtration methods as well as low or high pressure membranes. Because membrane technologies are core components of subsystems within larger plants, some of the companies that we captured are concerned with not only optimizing the membrane equipment itself but the entire subsystem.

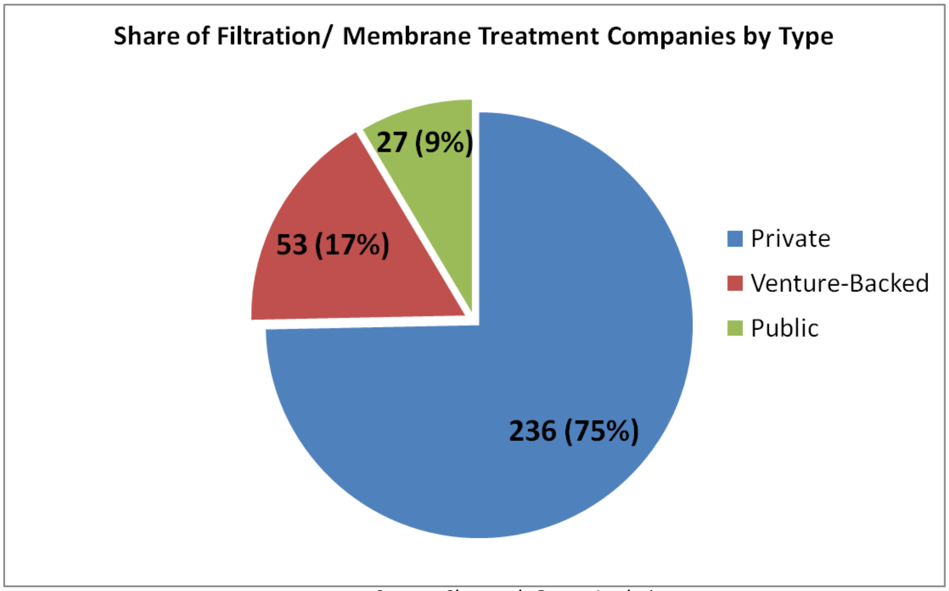
Membrane Product Landscape



Source: Cleantech Group Analysis

We estimate a total of U.S. spending across the Filtration/ Membrane Treatment segment will be approximately $0.07 billion in 2010. This estimate is based on analysis of third party data, interviews, and our own internal analysis.

Our analysis indicates that 75% (236) of the filtration/membrane companies that we catalogued are private, 17% (53) are venture-backed and 9% (27) are public. Similarly with the many private players we identified in the Water Treatment/ Disinfection segment, such companies are often in the difficult position of sitting in between the interest of the venture capital and private equity community.



Source: Cleantech Group Analysis

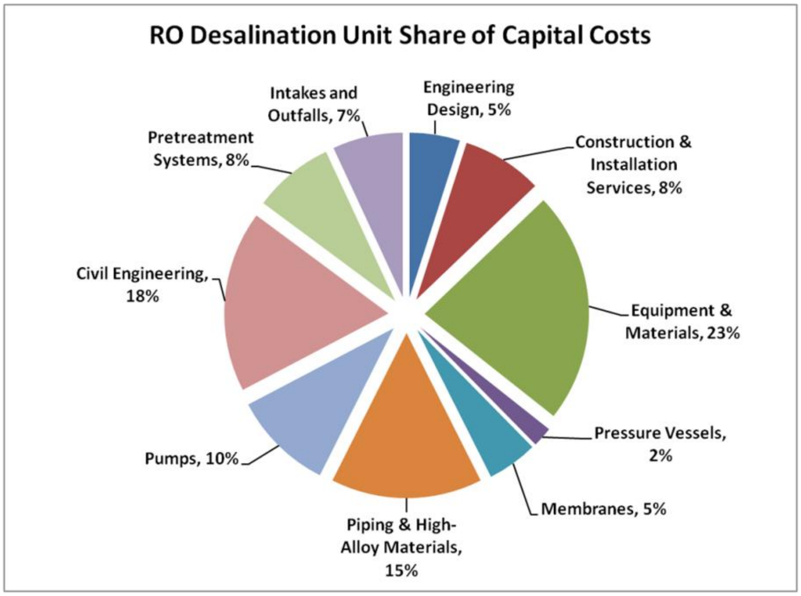
While technology advances in membrane technology have improved the energy requirements of RO membranes in desalination they are still subject to the laws of thermodynamics, which means that a minimum of 0.8 kWh/m3 of energy is required. According to Global Water Intelligence, the best performing RO membranes utilize between 3.8 – 4.2 kWh/ m3. Because RO membranes have now been standardized in RO systems, the membranes themselves have been commoditized and with the leading six suppliers highlighted in the table below.

RO MEMBRANE LEADERS

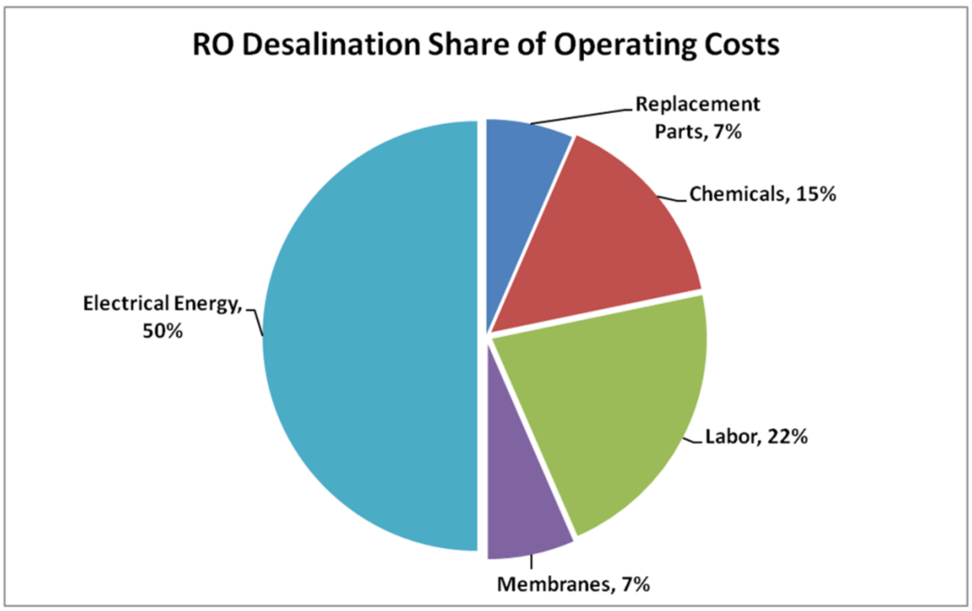
Company	Established	Key Acquisitions/ Transactions
DOW Water & Process Solutions		Zhejiang Omex Environmental Engineering
HYDRANAUTICS www.membranes.com A Nitto Denko Company	1975	Aquired by Nitto Denko in 1987
TORAY	1926	Ropur and Suido Kiko Kaisha
KOCH MEMBRANE SYSTEMS	1960	Romicon, Fluid Systems Corp., Puron
CSM	1972	
TOYOBO	1914	

Source: Cleantech Group Analysis

Still, RO systems are but one subsystem within a broader desalination plant and indeed, the RO membranes in terms of the initial capital outlay and operating costs account for 5% and 7% respectively of the total plant.



Source: Global Water Intelligence, Cleantech Group Analysis



Source: Global Water Intelligence, Cleantech Group Analysis

Engineering procurement and construction (EPC) firms compete with each other to buy the same parts from the same suppliers. And since the margins for designing and building such plants are so thin, EPCs often broaden their role in such projects by providing operations assistance or else working with a project developer to take an equity share in the project. While there is some scope to employ process engineering to deliver water at a lower cost, this is a not a patentable proposition, which leads to EPCs gaining only a short-term edge in terms of cost.

The main areas where EPCs can innovate will be the overall optimization of the RO process across the core subsystems: (1) Pretreatment, (2) RO membrane units and (3) energy recovery devices.

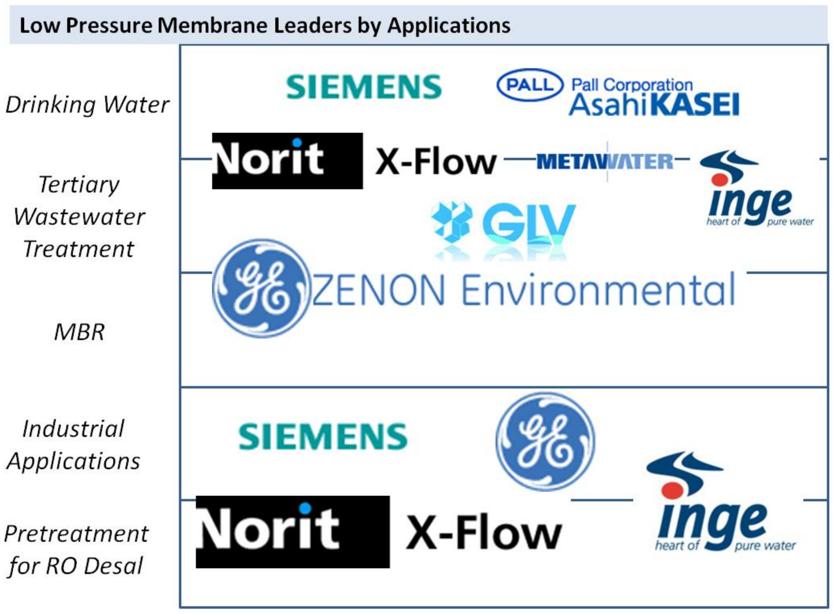
RO Desalination Plant Subsystems

Source: Cleantech Group Analysis

Pretreatment

The pretreatment process for RO systems is critical in the prevention of fouling and scaling of the RO membranes. While the pretreatment method depends on the feedwater quality, the success of an RO plant is often associated with the effectiveness of the pretreatment system. Today, the typical pretreatment process involves coagulation and flocculation followed by sand and then cartridge filtration. Increasingly, UF membranes are being used for pretreatment as they offer a solution to the removal of microorganisms and provides guaranteed feedwater quality, while reducing the amount of chemicals required to pretreat the water.

Not only are low pressure UF and MF membranes gaining market share in desalination applications, they are enjoying growth in drinking water, tertiary wastewater treatment, membrane bioreactors and various industrial applications. UF/ MF membranes are not yet commoditized and thus are sold either as systems or else with a great deal of engineering support from the supplier to ensure that system configurations comply with membrane warranties.



Source: Cleantech Group Analysis

RO Membrane Unit

According to Global Water Intelligence, 43% of RO membrane sales now go to industrial customers while the remaining share is sold for applications in desalination. Since RO membranes were first developed in 1965, significant improvements in flux rates and reductions in price has assisted the seawater RO desalination price to drop from $10/m3 in 1980 to $1/m3 in 2008.

Energy Recovery Devices

Two thirds of the feedwater in a RO desalination plant does not actually go through the membrane and is instead washed out as part of the high pressure brine stream that goes back to the sea. Energy recovery devices aim to capture this wasted energy by reapplying it to the feedwater stream. There are three main types of energy recovery devices: (1) Pelton wheels or energy recovery turbines, (2) Isobaric devices or work exchangers and (3) turbo chargers.

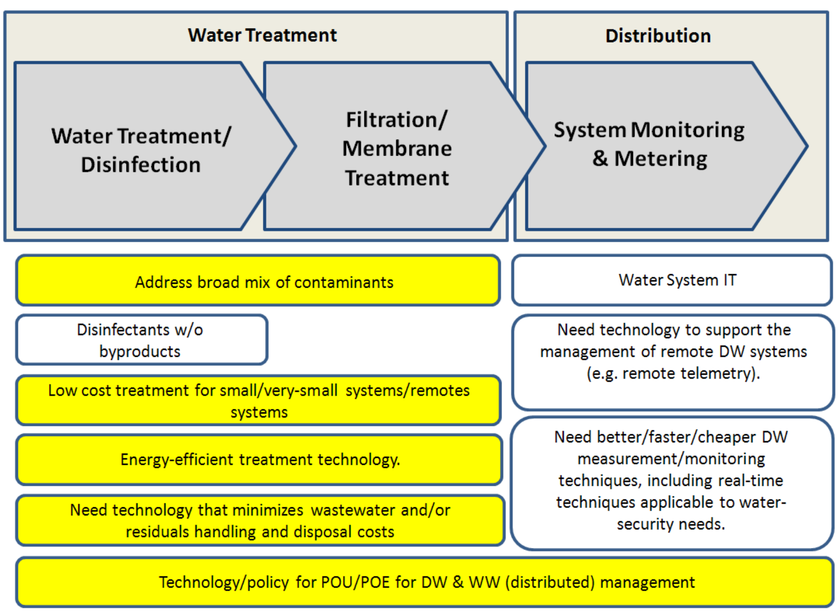
Energy Recovery Devices

Pelton Wheels	Isobaric Devices	Turbo Chargers
Energy recovery turbines. **90% Efficiency**	Utilize the direct pressure of the brine stream to add to the pressure on the feedwater. **97% Efficiency**	Brine flow directed towards a centrifugal impeller that shares a shaft with high-pressure centrifugal pump supplying the feedwater to the membranes. **90% Efficiency**.

Source: Cleantech Group Analysis

Recent consolidation in the market includes Texas-based Flowserve's acquisition of Switzerland-based Calder in April of 2009 as well as California-based ERI's acquisition of Michigan-based Pump Engineering.

In the following section, we will address each drinking water challenge area as it relates to the early-stage innovation that we identify within the context of the current vendors and dynamics of the membrane treatment market.



Emerging Innovation

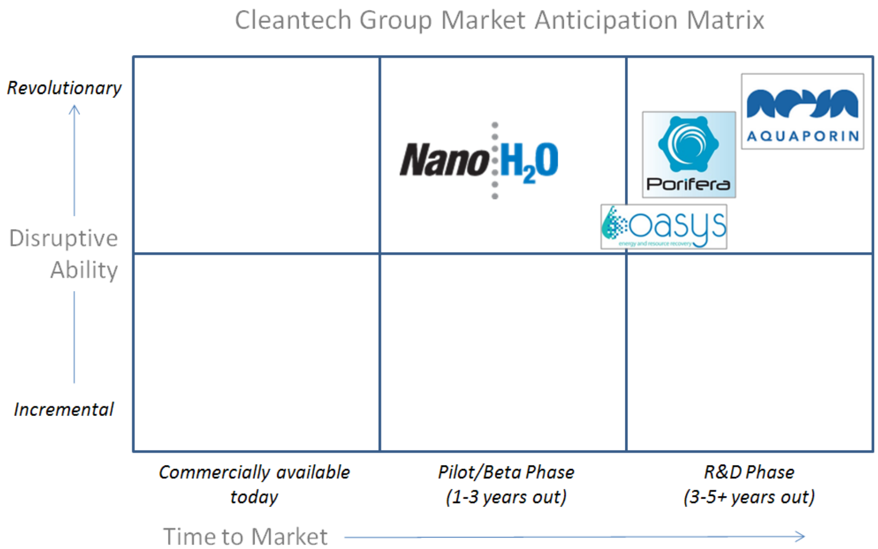
It is in this context of the membrane market that innovators are increasingly concerned with developing more efficient membrane filtration methods that not only control pathogens and filter a diversity of contaminants but do so utilizing less energy and by-products or waste.

Recently Funded Membrane Treatment/Filtration Companies (Funding in 2009 or 2010)

Company	Country	Description	Most Recent Capital Raise
Seven Seas Water Corp. (AquaVenture)	USA	Provider of seawater desalination and wastewater recycling plants in which the water can be reused for plant, lawn, and golf course irrigation.	$15,000,000
BPT	Israel	Developer of nano filtration membranes and systems for waste water treatment.	$12,000,000
Oasys Water	USA	Developer of a forward osmosis desalination technology.	$10,000,000
Inge AG	Germany	Developer of ultrafilter membranes and modules for the treatment of drinking water.	$6,958,000
Voltea	United Kingdom	Provider of desalination solutionst hat requires less power and no chemicals.	$4,600,000
Likuid Nanotech	Spain	Developer of inorganic membranes for filtration processes.	$2,700,000
nano-porous solutions Ltd.	United Kingdom	Developers of multi-layer adsorbent hollow fibre material used in separation and filtration processes.	$1,170,000
Nordaq	France	Provider of water purification solutions.	$690,000
Advanced Hydro Inc.	USA	Developer of a technology to reduce fouling of membranes used for water purification and filtration systems by using a deposition technique to adhere Polydopamine, a highly hydrophilic polymer onto	$500,000
Rotec Ltd	Israel	Producer of reverse osmosis technologies.	$100,000

Source: Cleantech Group Analysis

We have identified four vendors that are offering innovative membrane technologies:



Denmark-based **Aquaporin** is developing a biomimetic membrane capable of separating and purifying water from all other compounds based on nature's own method. Aquaporins act like water channels which selectively allow water molecules to pass through in single file while the transport of ions, protons and hydroxyl ions is abrogated by an electrostatic tuning mechanism.

The key advantage of Aquaporin's membranes is that it is 100 times more permeable than commercial RO membranes. At the moment, stability and strength to withstand the operating pressures and repeated fouling and cleaning expected in full-scale operations remain unknown. The technology is currently in basic and applied research.

AQUAPORIN **Denmark**

Overview: Development of a biomimetic membrane capable of separating and purifying water from all other compounds based on nature's own method, aquaporins.

Development Stage: Basic & Applied Research

How does it work? Aquaporins act as water channels which selectively allow water molecules to pass through in single file while the transport of ions, protons and hydroxyl ions is abrogated by an electrostatic tuning mechanism of the channel interior.

Advantages: 100 times more permeable than commercial RO membranes.

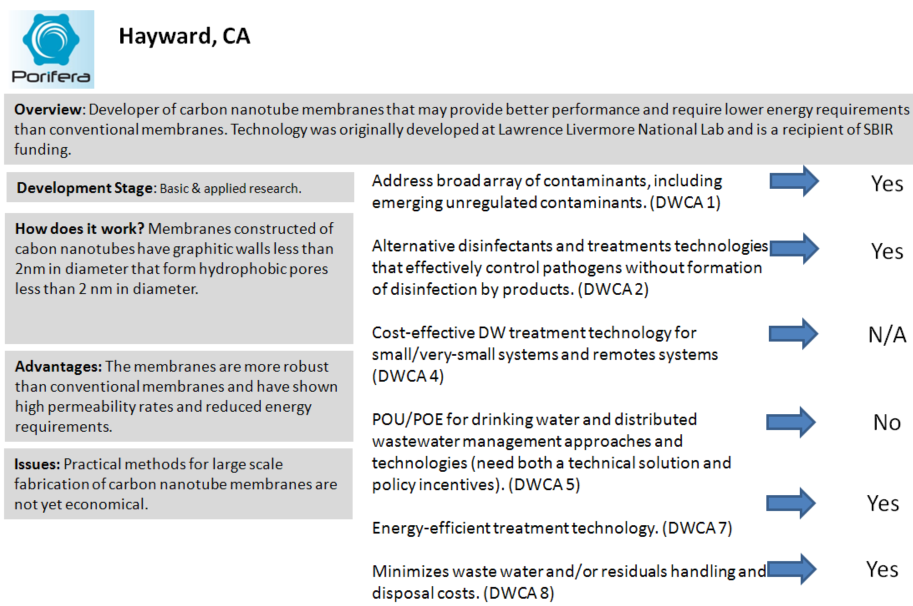
Issues: Stability and strength so they are able to withstand the operating pressures and repeated fouling and cleaning expected in full-scale operations.

Applications: Ultrapure process water, water reuse

Address broad array of contaminants, including emerging unregulated contaminants. (DWCA 1)	Yes
Alternative disinfectants and treatments technologies that effectively control pathogens without formation of disinfection by products. (DWCA 2)	Yes
Cost-effective DW treatment technology for small/very-small systems and remotes systems (DWCA 4)	N/A
POU/POE for drinking water and distributed wastewater management approaches and technologies (need both a technical solution and policy incentives). (DWCA 5)	No
Energy-efficient treatment technology. (DWCA 7)	Yes
Minimizes waste water and/or residuals handling and disposal costs. (DWCA 8)	Yes

Hayward, California-based **Porifera** is developing a carbon nanotube membrane that may provide better performance and require lower energy requirements than conventional membranes. The technology was originally developed at Lawrence Livermore National Lab and is a recipient of SBIR funding. Membranes constructed of carbon nanotubes have graphitic walls less than 2 nanometers in diameter that form hydrophobic pores.

Advantages of this technology are that the membranes are more robust than conventional membranes and have shown high permeability rates and reduced energy requirements. The problem is that practical methods for large scale fabrication of carbon nanotube membranes are not yet economical. The company is currently in basic and applied research.



Cambridge, Massachusetts-based **Oasys** is developing an engineered osmosis process employing an ammonium/carbon dioxide draw solution developed at Yale University. The company has received a $10 million Series A round of funding. Osmosis refers to the spontaneous diffusion of water from a low concentration of semipermeable membrane to a higher concentrated solution referred to as the draw solution. The process driven by the difference in the solutions' osmotic pressure and continues until the osmotic pressure on both sides reaches equilibrium.

oasys energy and resource recovery — **Cambridge, MA**

Overview: Developer of an engineered osmosis process employing an ammonium/carbon dioxide draw solution developed at Yale University. The company has received a $10 million Series A round of funding.

Development Stage: Applied Research - Pilot

How does it work? Osmosis refers to the spontaneous diffusion of water from a low concentration solution through a semipermeable membrane to a higher concentrated solution referred to as the draw solution.

The process is driven by the difference in the solutions' osmotic pressure and continues until the osmotic pressure on both sides reaches equilibrium.

Advantages: Ability to produce both fresh water and power through the FO process.

Issues: Lack of commercially available forward osmosis membranes.

Applications: Drinking Water, Desal

Address broad array of contaminants, including emerging unregulated contaminants. (DWCA 1)	Yes
Alternative disinfectants and treatments technologies that effectively control pathogens without formation of disinfection by products. (DWCA 2)	Yes
Cost-effective DW treatment technology for small/very-small systems and remotes systems (DWCA 4)	N/A
POU/POE for drinking water and distributed wastewater management approaches and technologies (need both a technical solution and policy incentives). (DWCA 5)	Yes
Energy-efficient treatment technology. (DWCA 7)	Yes
Minimizes waste water and/or residuals handling and disposal costs. (DWCA 8)	Yes

The advantages of this technology are its ability to produce both fresh water and power through the forward osmosis process. The downside is the lack of commercially available forward osmosis membranes. Currently, the company is in applied research and piloting stage.

El Segundo, California based **NanoH2O** has developed a thin film nanocomposite (TFN) membrane. The company has nano-engineered the porosity of a membrane at a molecular level to ensure that pores are straight, requiring less flux as well as fouling and scaling.

The advantages of the technology is its ability to decrease the capital cost of the system and reduce total energy costs by 25%. At the moment, however, the company is piloting the membrane to test its reliability at full scale. Interestingly, for purposes of assessing the role of various value chain participants, NanoH20 has a strong working partnership with Veolia Water to bring this technology to market.

NanoH2O El Segundo, CA

Overview: Developer of a thin film nanocomposite (TFN) membrane

Development Stage: Applied Research - Pilot

How does it work? One of the reasons why RO membranes require a tremendous amount of energy is because the pores in the membranes are not straight, requiring flux. TFN offers the possibility of engineering the porosity of a membrane on a molecular level that could also enjoy the advantages of being less prone to fouling and scaling.

Advantages: Improvement of the performance of the membrane could result in an overall decrease in the capital cost of a system and a total energy cost reduction of 25%.

Issues: Yet to be proven reliably on a large scale.

Applications: Drinking Water, Desal

Address broad array of contaminants, including emerging unregulated contaminants. (DWCA 1) →	Yes
Alternative disinfectants and treatments technologies that effectively control pathogens without formation of disinfection by products. (DWCA 2) →	Yes
Cost-effective DW treatment technology for small/very-small systems and remotes systems (DWCA 4) →	N/A
POU/POE for drinking water and distributed wastewater management approaches and technologies (need both a technical solution and policy incentives). (DWCA 5) →	Yes
Energy-efficient treatment technology. (DWCA 7) →	Yes
Minimizes waste water and/or residuals handling and disposal costs. (DWCA 8) →	Yes

IV. System Monitoring & Metering

Key Takeaways

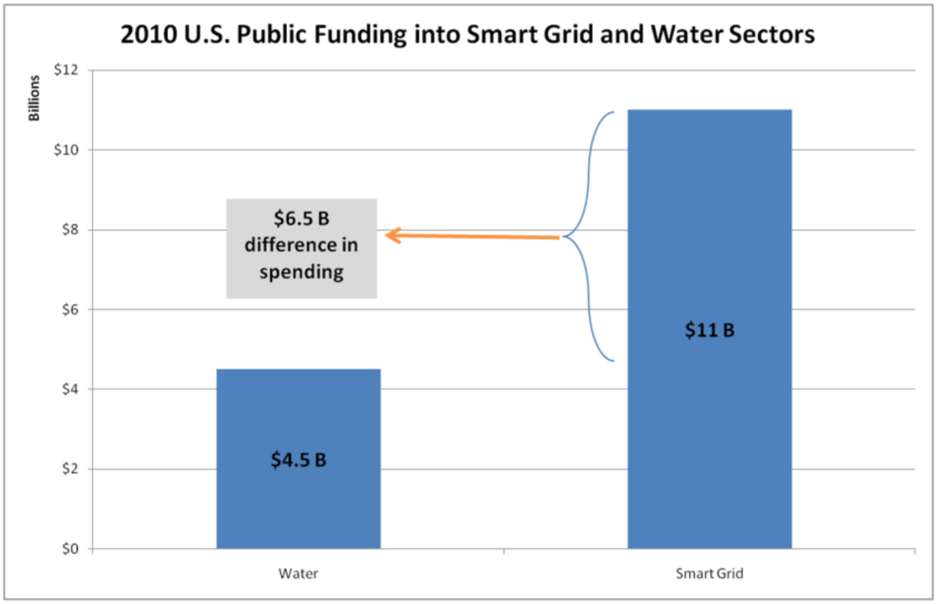
- Near real-time remote monitoring of water quality for municipalities is the ultimate goal of analytical capabilities, but significant development is required to make this a reality.
- Established instrumentation for the detection of flow rates will become increasingly critical for intensive water users to monitor and become more efficient with use and footprinting.
- Utilization of existing data to detect anomalies in distribution systems will allow municipalities to create efficiencies with existing infrastructure and upgrades by addressing non-revenue water in the short term.
- Metering technology is improving and innovation from other sectors, namely smart grid technologies for electric utilities, are slowly being brought to bear in the water sector; adoption of smart metering amongst water utilities has lagged that of gas and electric utilities.

Key Vendors

- Badger Meter Inc.
- American Micro Detection Systems
- Itron
- Loviband
- ABB
- Schneider Electric
- Merck
- Siemens
- GE Ionics
- Hach of Danaher
- ThermoScientific
- Pressure Pipe Inspection Systems
- Pure Technologies
- Bruker
- Perkin Elmer
- Oxford Instruments
- Takadu
- Aquarius Spectrum
- TACount

System monitoring & metering involves technologies concerned with water quality management, distribution network & process control management, and automated metering. Both government and private sector support of an electric smart grid has brought attention to the potential analogy of a water smart grid. Relative spending in venture-grade companies to support an electric smart grid, however, dwarfs dollars spent into water smart grid technologies.

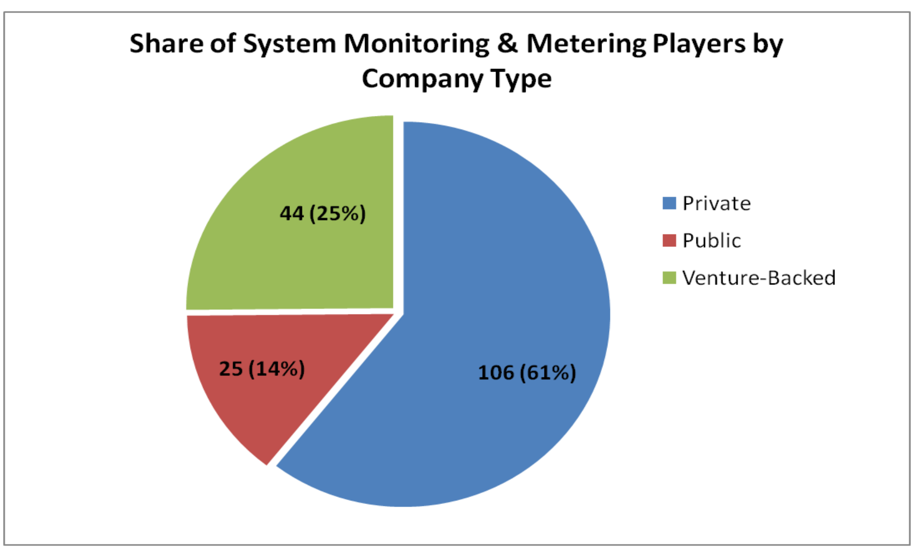
In addition, the American Recovery and Reinvestment Act (ARRA) electric smart grid investments and broader package of grid-related products exceeded similar spending going into water infrastructure upgrades by $6.5 billion in 2010. Unlike smart grid investments, where a significant portion of funding was allocated to projects that would directly benefit venture-grade companies, investments in the water sector were dedicated only to infrastructure upgrades.



Source: EPA Data, Cleantech Group Analysis

Despite this gap in funding, the system monitoring & metering market is growing steadily. **We estimate a total of U.S. spending across the System Monitoring & Metering segment will be approximately $0.88 billion in 2010**. This estimate is based on analysis of third party data, interviews, and our own internal analysis.

Our analysis indicates that 61% (106) of the System Monitoring & Metering companies that we catalogued are private, 25% (44) are venture-backed and 14% (25) are public. While private companies still dominate the list, venture activity in this particular space is healthy – relative to other water segments. The intersection of water and information technology (IT) is a comfortable space for many venture capitalists; the need for efficient and remote water quality monitoring and distribution & process control management are increasingly critical for municipal and industrial water users.



Source: Cleantech Group Analysis

Water Quality Management

Time efficient water quality management remains the holy grail for not only drinking water utilities but also for industries like food and beverage where the public health scare of recalls subjects companies to litigation and reputational risks. In recent weeks, the interest in such real-time monitoring was illustrated by **Badger Meter**'s minority stake in **American Micro Detection Systems** (**AMDS**) to help the company finalize the development of their REX Sensor, which has the ability to detect dissolved metals down to the parts-per-billion in real-time. AMDS is also working on a second sensor product that will be able to detect hazardous organic chemicals that could act as a stepping stone to the real-time detection of other contaminants in drinking water, wastewater and process water applications.

The quality management of water, however, is complex as there are approximately 100 substances that are regulated and require testing on a regular basis. Whether for drinking water, swimming pools or water utilized for the beverage industry variables to be tested range from chlorine levels, biochemical oxygen demand (BOD) and the presence of microorganisms such as cryptosporidium and legionella. Water quality testing in and of itself is one market.

Sample of Tested Contaminants

Groundwater	Drinking Water	Wastewater	Industry – (Beverage, Power, Chemicals)	Commercial – Recreation/ Aquatics
• Volatile organic compounds (VOCs) • Polychlorinated biphenyls (PCBs) • Herbicides •Pesticides •Nitrogen • Phosphorous • Magnesium nutrients	• Chlorine levels • Biochemical oxygen demand (BOD) • Microorganisms	• Chlorine levels • Biochemical oxygen demand (BOD) • Microorganisms	• Chemical concentrations	• Chlorine levels • Biochemical oxygen demand (BOD) • Microorganisms

Water testing facilities are estimated at approximately 1,300. Many of these laboratories are in-house and embedded in major water use facilities like municipal water and wastewater plants, beverage bottlers, breweries and pharmaceutical manufacturing plants. Tests that are done in commercial laboratories typically cater to a regional need within a small geographic area.

Equipment providers supplying analytical instrumentation are divided into (1) onsite treatment equipment, (2) In-line monitors and (3) high-end testing devices.

Specialty Analytics & Instrumentation Equipment

Onsite Test Equipment	In-Line Monitors	High End Testing Devices
E.g. swimming pool chlorine samplers	Often used in industrial settings to supply real-time measurements from flowing liquids.	e.g. gas chromatography and mass spectrometry used by special technicians in laboratories.
LaMotte, Lovibond, MERCK Be well, Palintest®, ThermoFisher SCIENTIFIC	SIEMENS, HACH®, GE	BRUKER, PerkinElmer For the Better, OXFORD INSTRUMENTS, ThermoFisher SCIENTIFIC

Source: Cleantech Group Analysis

Distribution and System Management

Large information technology (IT) players including **Cisco**, **IBM** and **Oracle** are increasingly interested in the water business and the opportunity to find convergence between IT and water – specifically where data aggregation, management and control are concerned. Some water industry veterans, however, argue that there is a limit to the role of IT in water, where environments are harsh and regulation is extremely thick. One large corporate vendor went so far as to say that it is not in the interest of a company to identify and measure unregulated contaminants so as to avoid any potential liability.

Meanwhile, innovators have been addressing the non-revenue water loss through leaks in Europe and North America's aging infrastructure. An estimate of 30% of treated water is lost through leaks in aging distribution systems.

System Input Volume	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption (including water exported)	**Revenue Water**
			Billed Non-metered Consumption	
		Unbilled Authorized Consumption	Unbilled Metered Consumption	**Non-Revenue Water**
			Unbilled Non-metered Consumption	
	Water Losses	Apparent Losses	Unauthorized Consumption	
			Metering Inaccuracies	
		Real Losses	Leakage on Transmission and/or Distribution Mains	
			Leakage and Overflows at Utility's Storage Tanks	
			Leakage on Service Connections up to Customers' Meters	

Source: Cleantech Group Analysis

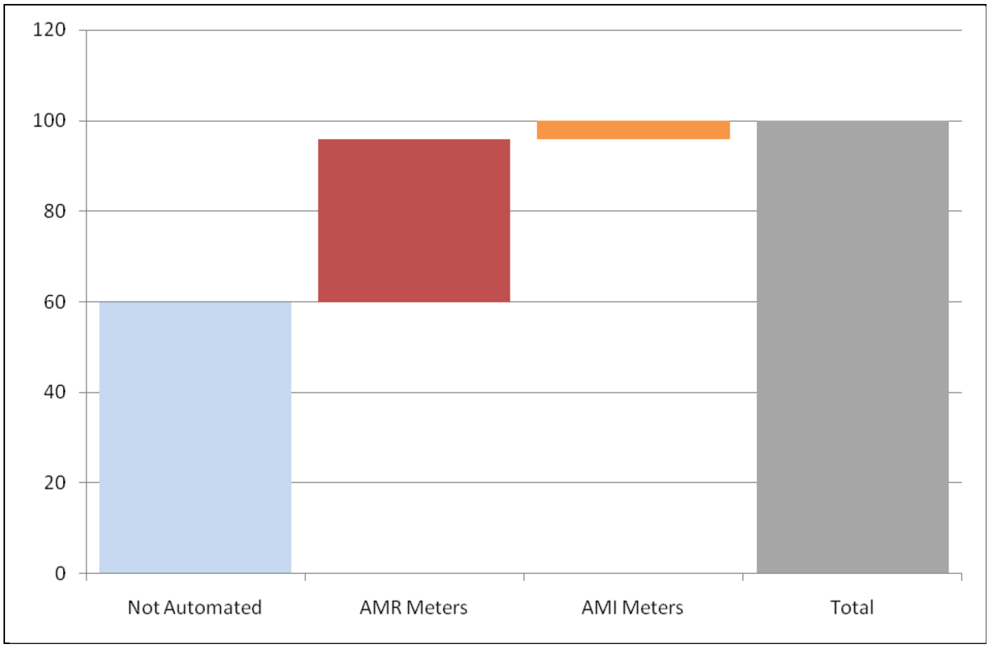
Activity in this segment is increasing steadily as are the issues surrounding innovative water resource management approaches. For example, Canadian-based **Pure Technologies**, developer of acoustic monitoring systems for monitoring and management of infrastructure acquired Emerald Technology Ventures company, **Pressure Pipe Inspection Co**. (PPIC) to broaden the company's international expansion. PPIC currently has customers not only in North America but South America, the Philippines and Hong Kong. And large IT players like IBM are partnering with startups like Takadu – an early stage player we profile later on.

Automated Metering

For all of the investor and public attention to "smart meters" for electric utilities, the evolution of automated meter reading in the water sector has lagged the adoption of similar technology in the electric and gas sector. According to most industry estimates, there are approximately 100 million water meters in the United States. Of this total, approximately 40% have been outfitted with first generation automated meter reading (AMR).

AMR meters integrate communication units to transmit data in at least one direction. Most of these meters are RF (radio frequency) devices that are read by drive-by or handheld receivers. These meters have steadily, albeit slowly, been replacing legacy meters that required visual inspection. The second generation of AMR meters, known as AMI (advanced metering infrastructure) or "smart meters" allow for bi-directional communication to/from the meter primarily over fixed wireless networks. AMI deployments have seen fast adoption amongst electric utilities that received funding through the American Recovery and Reinvestment Act of 2009 to invest in these implementations.

Distribution of U.S. Water Metering Technologies

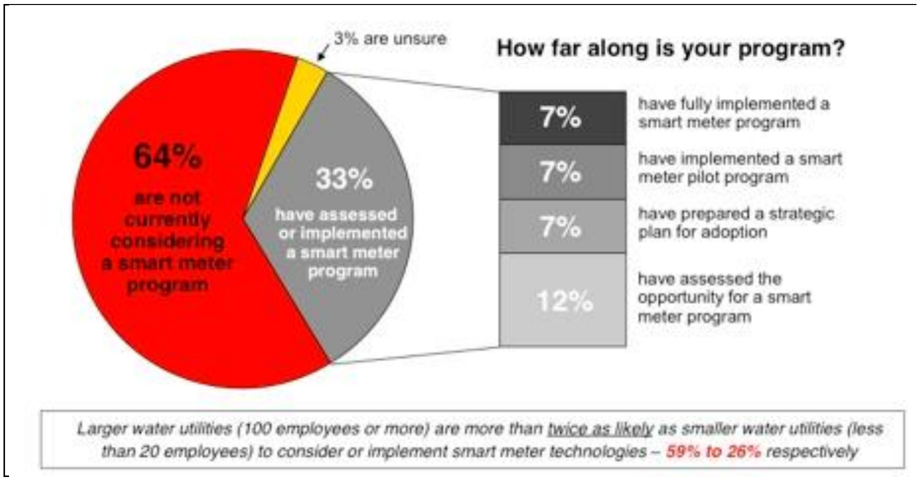


Source: Itron, Badger Meter, IMS Meter Report, Scott Report, Cleantech Group Analysis

Water utilities have not been as quick to deploy AMI units. We estimate that only 10% of the 40 million AMR units deployed by water utilities, or approximately 4 million, would be classified as AMI. As a comparison, electric utilities will have deployed approximately 20 million AMI units by the end of 2010 according to the Cleantech Group's 2010 U.S. Smart Grid Vendor Ecosystem Report commissioned by the U.S. Department of Energy.

These estimates are in line with a recent water utility study published by Oracle [8]. The study indicated that only 7% of utilities have implemented a smart meter program with an additional 7% in pilot phases. A majority of utilities in this study, and the vast majority of smaller utilities, have not yet considered a smart meter program.

[8] http://www.environmentalleader.com/2010/01/11/33-of-water-utilities-adopting-smart-meters/?graph=full&id=1



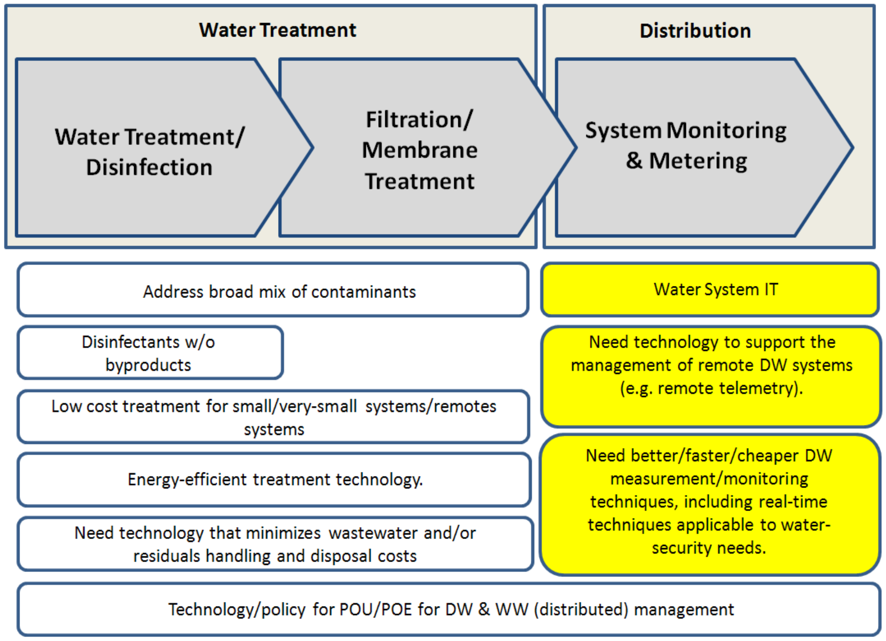
Source: Oracle, Environmental Leader

While AMI meters hold the promise of not only enabling consumers to better understand water usage, but also the operational benefit of enabling utilities to more accurately identify leaks and operational problems, the investment in this next wave of technology has not yet been compelling for most utilities. The one benefit of this delayed deployment is that AMI technology continues to mature through its deployment to electric and gas utilities. Reliability should increase over time and costs should decline enabling water utilities to reap these returns to scale on future implementations.

The U.S. water metering market has been dominated by a small number of large, established vendors: Badger Meter, Neptune, Itron, Elster, and Master Meter account for the majority of automated meters deployed. Advanced metering, in particular next generation communication infrastructure, has garnered a significant amount of venture capital with companies such as Silver Spring Networks and Trilliant receiving large investments. These companies have primarily targeted electric utilities, but are beginning to penetrate the water market. It should be noted that these venture-backed innovators do not actually manufacture meters, but rather focus on communication units and partner with vendors such as Itron, GE, and Landis+Gyr that integrate communication units into meter hardware.

We expect that the automated and advanced water metering market will grow as the economic drivers to manage and conserve water more efficiently become more acute. Rising energy prices and the desire of both consumers and utilities to better manage electricity use, has been the driving force behind deploying more advanced metering infrastructure in the electric grid. As the water industry begins to experience similar pressure, we will see analogous needs develop.

In the following section, we will address each drinking water challenge area as it relates to the early-stage innovation that we identify within the context of the current vendors and dynamics of the System Monitoring & Metering market.


Water Treatment
Distribution
Water Treatment/ Disinfection
Filtration/ Membrane Treatment
System Monitoring & Metering
Address broad mix of contaminants
Water System IT
Disinfectants w/o byproducts
Need technology to support the management of remote DW systems (e.g. remote telemetry).
Low cost treatment for small/very-small systems/remotes systems
Energy-efficient treatment technology.
Need better/faster/cheaper DW measurement/monitoring techniques, including real-time techniques applicable to water-security needs.
Need technology that minimizes wastewater and/or residuals handling and disposal costs
Technology/policy for POU/POE for DW & WW (distributed) management

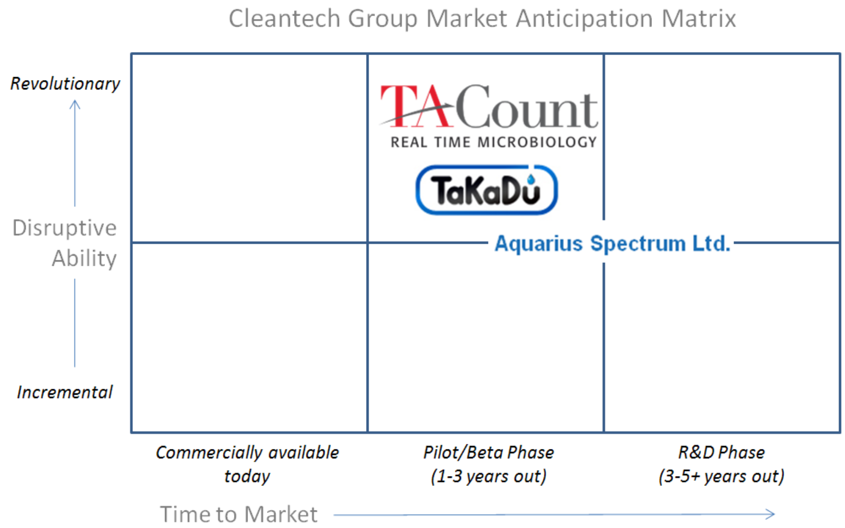
Emerging Innovation

It is therefore in this context of the System Monitoring and Metering market that innovators are increasingly concerned with developing more flexible water systems and creating efficiencies with current systems.

Recently Funded System Monitoring & Metering Companies (Funding in 2009 or 2010)

Company	Country	Description	Most Recent Capital Raise
i20 Water	United Kingdom	Developer of a smart metering and pressure control system that ensures the average zone pressure in pipes is kept to the minimum required, leading to reduced leaks and bursts.	$6,350,000
Hydrelis	France	Developer of leak detection systems and water management systems.	$4,500,000
Intellitect Water	United Kingdom	Developer of water quality sensors and instruments.	$3,300,000
Aqualabo	France	A provider of instruments and probes for water quality monitoring, checking and analysis.	$2,800,000
Checklight, Ltd.	Israel	Developer of real-time water quality testing and monitoring kits and products.	$2,000,000
Cyber-Rain, Inc.	USA	Developer of water management systems for smart sprinkling homeowners' landscapes.	$1,800,000
Sorbisense ApS	Denmark	Developer of water quality monitoring technology for a variety of sources including drains, groundwater, drinking water, and industrial wastewater.	$1,200,000
Shaw Water Engineering	United Kingdom	Developer of Crypto-Tect" technology to detect the presence of harmul parasites in fresh water supplies."	$1,190,000
Checklight, Ltd.	Israel	Developer of real-time water quality testing and monitoring kits and products.	$1,000,000
Sens-Innov	France	Sensors for water pollution detection.	$640,000
Aquarius Spectrum	Israel	Developers of online water leak detection system for municipalities.	$500,000
Checklight, Ltd.	Israel	Developer of real-time water quality testing and monitoring kits and products.	$500,000
Ecochemtech Ltd.	Israel	Developers of a self-powered water monitoring system.	$500,000
Hydrospin Ltd.	Israel	Developers of inside pipe generator that supplies electricity for water monitoring and control systems.	$500,000
Sorbisense ApS	Denmark	Developer of water quality monitoring technology for a variety of sources including drains, groundwater, drinking water, and industrial wastewater.	$461,000
EnPrint	United Kingdom	Applied DNA fingterprinting technology to deliver accurate assessment of water quality.	$248,400
BiAqua	Netherlands	Developer of bio-based contamination detection in water treatment.	Undisclosed
Echologics Engineering, Inc.	Canada	Developer of an acoustic technology for leak detection in pipes.	Undisclosed
Smartap	Israel	Developer of smart residential water solutions.	Undisclosed
SPC Tech Ltd.	USA	Developers of smart pressure control system to prevent leaks.	Undisclosed
TaKaDu	Israel	Developer of a water management software.	Undisclosed

Source: Cleantech Group Analysis



We have identified three vendors that are offering innovative System Monitoring & Metering technologies:

Israel-based **TaKaDu** is a Software-as-a-Service (SaaS) solution providing water utilities with Water Infrastructure Monitoring. TaKaDu detects, alerts and provides real-time insight on leaks, bursts and network inefficiencies. Complex statistical algorithms correlate and analyze existing online data from meters within the network (such as flow, pressure, quality, etc) and external data (weather, holidays and more), allowing water utilities worldwide to efficiently manage their networks. The technology requires no changes to the network, no additional devices and no capital expenditure.

Israel

Overview: TaKaDu is a Software-as-a-Service (SaaS) solution providing water utilities with Water Infrastructure Monitoring. TaKaDu detects, alerts and provides real-time insight on leaks, bursts and network inefficiencies.

Development Stage: Pilot - Commercialization

How does it work? Complex statistical algorithms correlate and analyze existing online data from meters within the network (such as flow, pressure, quality, etc) and external data (weather, holidays and more), allowing water utilities worldwide to efficiently manage their networks. The technology requires no changes to the network, no additional devices and no capital expenditure.

Water System IT	Yes
IT for remote DW systems (e.g. remote telemetry). Cost-effective DW treatment technology for small/very-small systems and remotes systems	N/A
Cost effective, smart, secure real time monitoring techniques.	Yes

Israel-based **Aquarius Spectrum** is developing a wireless sensor network to provide online monitoring and detection of water leaks. The system is powered by algorithms for leak detection in complex pipeline networks and is based on distributed signal process and ultra low power communication system enabling up to 4 years maintenance free operation.

Aquarius Spectrum Ltd. **Israel**

Overview: Developer of a wireless sensor network to provide online monitoring and detection of water leaks. .

Development Stage: Pilot - Commercialization	Water System IT	Yes
How does it work? The system is powered by algorithms for leak detection in complex pipeline networks and is based on distributed signal process and ultra low power communication system enabling up to 4 years maintenance free operation.	IT for remote DW systems (e.g. remote telemetry). Cost-effective DW treatment technology for small/very-small systems and remotes systems	N/A
	Cost effective, smart, secure real time monitoring techniques.	Yes

Israel-based **TA Count** is developing a rapid microbiology technology that can enable the detection and counting of microorganisms in a matter of minutes. By detecting culturable / colony forming microorganisms only, it provides a CFU count equivalent to what would be obtained using plate count method. The technology is based on the discovery of a specific intracellular activity.

A key advantage of the technology is its broad application area beyond drinking water. It can be applied in wastewater pharmaceuticals and food and beverage production line applications.

TACount REAL TIME MICROBIOLOGY **Israel**

Overview: Developer of a rapid microbiology technology that can enable the detection and counting of microorganisms in a matter of minutes.

Development Stage: Pilot - Commercialization	Water System IT	N/A
How does it work? By detecting culturable / colony forming microorganisms only, it provides a CFU count equivalent to what would be obtained using plate count method. The technology is based on the discovery of a specific intracellular activity.	IT for remote DW systems (e.g. remote telemetry). Cost-effective DW treatment technology for small/very-small systems and remotes systems	N/A
Advantages: Broad applications beyond drinking water: wastewater, pharmaceuticals and food and beverage product lines.	Cost effective, smart, secure real time monitoring techniques.	Yes